Accomplishments in Tobacco Research in North Carolina

2000269875

March 1, 1986 - February 28, 1987

This information presented in the annual report is NOT FOR PUBLICATION but represents preliminary findings which may later appear in published form. We trust that you will find this information of interest and value.

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PREFACE

The North Carolina Agricultural Research Service supported 62 projects on various aspects of tobacco research in 1986. Forty-eight faculty members from 8 of the 20 departments in the School of Agriculture and Life Sciences devoted 20.7 scientist years (full-time equivalence) to tobacco research. Total expenditures during 1986 were approximately $5.31 million, an increase of about $0.38 million over 1985. It is of interest to note that 18 years ago (1968), 34 faculty from nine departments devoted 24.6 scientist years to tobacco research with expenditures of approximately $1.4 million. Total support years for tobacco research in 1986 (includes scientists, technicians, post-doctorals, and clerical) were 97.8, down from 102.0 in 1985.

The USDA-ARS Oxford Tobacco Research Laboratory at Oxford, N. C. is an essential component of our total tobacco research program. The above data do not include federal dollars expended in support of this laboratory.

Supplemental support provided by growers, warehousemen, leaf exporters and manufacturers of tobacco products through the North Carolina Tobacco Foundation continues to stimulate project leaders to strive for a "margin of excellence" that might not be attainable with support only from appropriated funds. Tobacco Foundation allocations plus industry grants for research were approximately $558,000 with the majority received from the Foundation. Dr. Larry M. Sykes of Philip Morris, USA, provided outstanding leadership as President of the Foundation during his first term in 1985-86 and was re-elected President for the 1986-87 term.

Funds received for special activities or projects have greatly enhanced various aspects of the overall tobacco research program. Of particular importance has been support provided for the following: three post-doctoral fellowships on a continuing basis; an undergraduate research apprenticeship program, which enables up to eight outstanding undergraduate students to receive a research experience working with selected faculty; the graduate research assistantship supplement fund, which permits N. C. State University to attract the more promising students into graduate research programs on tobacco; the research equipment fund for assisting scientists in the purchase of needed scientific equipment; and expanded research effort in areas of varietal development, disease control, leaf quality and mechanization.

Since our last report Dr. James F. Chaplin, Director of the USDA Tobacco Research Laboratory at Oxford, N. C., retired after more than 30 years of government service. We wish him the very best in his retirement and commend him for his outstanding leadership and research accomplishments, which have greatly benefitted the U. S. tobacco industry. Mr. Dean Winter is serving as Interim Director until Dr. Chaplin's position is filled.

Also, Dr. Don De Jong, research plant physiologist, has been reassigned to the USDA Tobacco Research Laboratory at Oxford and will be working in the area of molecular genetics. We welcome Dr. De Jong back to North Carolina and to our "tobacco family".

We are pleased with the overall accomplishments in tobacco research in North Carolina during 1986, with the strength and broad scope of activities underway; and we look forward to 1987 with its challenges and new opportunities as we seek solutions to problems of importance to this great industry.

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Title: NC 03995 Biochemical Control of Senescence in Tobacco Leaves

Project Leader: Edward C. Sisler

I. Summary of Research:

This project has the following objective:

To study the ripening processes in tobacco leaves and to develop means of controlling these processes.

Evaluations of a number of compounds have been made as to their ability to interact with the ethylene-binding site in tobacco leaves.

It has previously been reported that molecular strain is an important factor in binding, and also that conjugated double bonds are more effective in binding than are isolated double bonds.

These ideas have been tested using $[^{14}C]$ethylene and tobacco leaves. For comparison, a Triton X-100 extract of mung beans was used (Table I).

Table I. Effect of Compounds on Ethylene Displacement

Compound	Triton X-100			Tobacco		
	K_d (gas)		K_d (liquid)	K_d (gas)		K_d (liquid)
	r	µl/l	M	r	µl/l	M
2,5-Norbornadiene	5.6	26	5.8×10^{-6}	0.939	223	7.91×10^{-6}
Cyclopentadiene	5.2	25	6.4×10^{-6}	1.0	330	1.33×10^{-5}
Furan	8.0	120	3.8×10^{-5}	4.8	2100	4.06×10^{-4}
Pyrrole	80.0	790	2.5×10^{-3}	173	6000	4.2×10^{-2}
Triophene	47.0	6060	1.15×10^{-2}	5.8		
1,3-Butadiene	1.33	166	8.9×10^{-6}	0.38	4700	7.2×10^{-5}
Methylcyclopentadiene	20.8	636	5.3×10^{-4}		4700	
Dicyclopentadiene	47.0	1340	2.5×10^{-3}			
Cycloheptatriene	5.1	2000	4.1×10^{-4}	0.36	3500	5×10^{-5}
2-Furonitrile		1440				
Furfurylamine	-	inactive				
2-Furfuryl alcohol	-	inactive				
2-Furoic acid	-	inactive				
2-Furoic acid hydrazide	-	inactive				
2-Furfuraldehyde	-					
Methyl pyrrole	101	1904	7.8×10^{-3}	67.0	12,000	3.2×10^{-2}

II. Special Student: Carmen Wood, R. J. Reynolds Research Apprentice.

IV. Publications:

Sisler, E. C., M. S. Reid, and S. F. Yang. 1986. Effect of antagonists of ethylene action on binding of ethylene in cut carnations. Plant Growth Regul. 4:213-218.

Brown, J. H., R. L. Legge, E. C. Sisler, J. E. Baker, and J. E. Thompson. 1986. Ethylene binding to senescing carnation petals. J. Exp. Bot. 37:526-534.

Goren, R., and E. C. Sisler. 1986. Ethylene-binding characteristics in Phaseolus, Citrus, and Ligustrum plants. Plant Growth Regul. 4:43-54.

Beggs, M. J., and E. C. Sisler. 1986. Binding of ethylene analogs and cyclic olefins to a Triton X-100 extract from plants: comparison with in vivo activities. Plant Growth Regul. 4:13-21.

Sisler, E. C., and C. Wood. 1986. Ethylene requirement for tobacco (Nicotiana tabacum) seed germination. Tobacco Sci. 30:97-99.

Sisler, E. C. 1986. Isoelectric focusing of the ethylene-binding component using immobilized ampholines. Plant Physiol. 80:S144 (Abstr).

Sisler, E. C. 1986. Ethylene binding and evidence that binding in vivo and in vitro is to the physiological receptor." Proceedings of the NATO Advanced Research Workshop on Plant Hormone Receptors, Aug. 18-22, Bonn, Federal Republic of Germany (Abstr).

V. Manuscripts Accepted for Publication:

Sisler, E. C., S. F. Yang. 1987. Ethylene. In "Model Building in Plant Physiology/Biochemistry" (Newman, D., and K. Wilson, eds), CRC Press, Inc., Boca Raton.

Sisler, E. C. 1987. Purification of the ethylene-binding component from mung bean sprouts and seeds. In "Plant Hormone Receptors," NATO Advanced Study Institute Series (Klämbt, D., ed), Springer Verlag, Berlin, Heidelberg, New York.

Sisler, E. C., and C. Wood. 1987. Ethylene binding and evidence that binding in vivo and in vitro is to the physiological receptor. In "Plant Hormone Receptors," NATO Advanced Study Institute Series (Klämbt, D., ed), Springer Verlag, Berlin, Heidelberg, New York.

Sisler, E. C. 1987. Induction of chlorophyllase in tobacco leaves by ethylene and auxin. Tobacco Sci.

VII. Papers Presented at Professional Meetings:

Sisler, E. C. 1986. Ethylene binding and evidence that binding in vivo and in vitro is to the physiological receptor. Presented at the NATO Advanced Research Workshop on Plant Hormone Receptors, Aug. 18-22, Bonn, Federal Republic of Germany.

Title: NC03801 Improved System for Transplant Production and Direct Seeding of Tobacco.

Project Leaders: C.W. Suggs and S.C. Mohapatra

I. Summary of Research:

Research during 1986 used seeds of Speight G-28 cultivar and were conducted under three major categories: A) Field trials on mechanized transplant production, B) Laboratory studies on seed germination and seedling development and C) Greenhouse production of transplants. Research accomplishments are therefore described in the following under these three categories and subcategories thereof.

A. FIELD TRIALS ON MECHANIZED TRANSPLANT PRODUCTION

All field trials were conducted at the Central Research Station, Clayton in either permanent plantbed locations or in field rows in the case of yield and value studies. Six studies were conducted as described below. The bed layout, seeding and undercutting equipment used for these studies was the same as those described in previous annual reports.

Unless otherwise mentioned, the following procedure for data collection and analysis was followed for each field experiment described. Germination was counted weekly for six weeks, then skipped for two weeks, and again counted for the final two weeks before transplanting. Thus, there were eight data groups covering a ten-week period. This approach was necessary because of unexpected inclement weather, without which the experiment was expected to be completed during the first eight weeks. Each sample site measured 12" x 6.75" and constituted one of the several subreplicates within a replicate, the number of which varied between studies depending on the statistical design in use. A new set of sample sites was used each week to avoid the effect of frequent cover removal and replacement. Samples from the final plant count site were transported to the laboratory for growth parameter measurement.

A new and simple method was developed as follows for quick comparison of seed treatments designed to improve germination rate.

$$\text{RER (Relative Emergence Rate)} = \frac{MGP}{W}$$

where: MGP = Maximum germination percentage and is calculated as

$$\frac{M}{E}$$

E = Expected seedling number, this is 27 for the sample site measuring 12" x 6.75"

M = Maximum (average) seedling number at the sample site

W = The week of plant count in which the maximum number of seedlings was obtained

The above approach is based on the assumption that a seed lot with a higher germination rate would give a higher number of seedlings than the seed lot with a slower germination rate at any given time, particularly before the arrival of the inclement weather. Thus the RER will be used in the following, where applicable, to compare various studies with respect to germination rate.

<u>Study #1 (Effect of Plant Size on Yield, Value, Chemistry and Growth)</u>:

A series of field trials over three years and two locations did not reveal any large or significant differences in yield, value and sugar and alkaloids concentrations due to transplant size, mixtures of plant sizes or shape. Small, medium and large plants were about 13, 20 and 30 cm tall, respectively with stem diameters of approximately 5, 6.5 and 8 mm. Tall-slim or spindley plants were of medium height but stems were only about one-half the diameter (3.2 mm) of the medium plants. Days to flower and growth rate data contained a few significant individual differences but trends were not evident. Flowering date was delayed and growth rate was higher for the long thin plants. Also, growth rate was lower for the large plants.

It can be concluded that transplant size and shape have little effect on yield, value, growth rate and sugar and alkaloids concentrations of the leaf. Good crops can be expected from a wide range of shapes and sizes of plants provided a stand can be established. These findings are of special importance to efforts to automatically harvest seedlings and feed them into a transplanter.

<u>Study #2 (Effect of Bare Root vs Intact Root Plants on Yield, Value, Growth Rate and Chemistry)</u>:

There were no significant yield or value differences between crop grown from paper-pot plants or bare-root plants. Crops grown from consolidated plug plants were generally lower in yield and value than crops from bare-root or tray-grown plants.

Growth rates for the first several weeks after transplanting were generally higher for intact-root plants (plug or paper pot) than for bare-root plants. However, the increase in growth rate was not sufficient to allow smaller intact-root plants to catch up with the larger bare-root plants as days to flower were significantly longer for the intact-root paper pot plants.

Sugar concentration in the cured leaf were generally lower for all of the plug plant treatments than for the bare-root check or the speedling plots. The effect of soil plugs on alkaloid concentration was mixed with some values larger and some smaller than the bare-root plants. Both sugar and alkaloids were unaffected by the paper pot method of plant production.

It can be concluded that tobacco yield, value and leaf sugar and alkaloids are not increased by the use of intact-root transplants. In fact, in one experiment sugar concentration was decreased and the mixed alkaloid results suggest that weather or other factors may have dominated the results. These results suggest that while good crops can be produced from intact-root plants there is little if any incentive to use intact-root plants except for the mechanization advantages which may develop with respect to self-feeding

transplanters.

<u>Study #3 (DPI Treatment vs Pellet Drilling)</u>: Mechanized seeding of coated seeds will be referred to hereafter as pellet drilling as compared to fluid drilling and hydroseeding of naked seeds. This experiment was conducted in collaboration with the Royal Sluis Co., Salinas, CA. DPI treated seeds and untreated seeds were coated by the Royal Sluis Co., who also added a proprietary treatment of their own. The latter is designated as RS-treatment. Table 1 shows the weekly progression of germination and RER for all the three treatments. These results show that both seed treatments improved germination rate over that of the control, but the DPI treatment gave much better results than the RS-treatment. This study will be repeated for several years before any firm conclusion can be made.

<u>Study #4 (DPI Treatment vs Fluid Drilling)</u>: This study was similar to the above study except that seeding was done through fluid drilling of naked seeds, and therefore, no RS-treatment was included. Again, data in Table 1 show that the DPI treated seeds had a much higher RER value than the untreated seeds. Comparison of data for Study #1 and #2 show that the untreated naked seed had a higher RER value than the untreated coated seed. It is not known at this time if the difference was due to adverse effect of the coating material/method or to the promotive effect of the fluid drilling materials/method.

<u>Study #5 (Germination Advancement)</u>: In this study, seeds were pregerminated under laboratory conditions for germination advancement for 24, 48, 72, and 96 hours. The timing was adjusted such that all seed lots would be available for seeding at the same time. The control constituted the 0-hour seed; and seeding was done through fluid drilling. This study had two major objectives: a) allowing the seeds to complete the rate limiting steps under favorable conditions in the lab and b) to permit late seeding without affecting the normal transplanting time. The latter would be especially useful if inclement weather did not permit seeding on time. As expected, RGR values increased with advancement in germination priod to seeding (Table 1). Also, as expected, the control (untreated) seeds performed about the same as in Study #3and #4.

<u>Study #6 (Hand Seeding vs Machine Seeding)</u>: A seed spacing of 3 in^2 is sought through mechanized seeding. Thus, a total of 27 plants would be expected at a sampling site measuring 12" x 6.75". The germination percentage obtained from the normal plant counting method can be misleading if operational error(s) resulted in the placement of more or less than the expected 27 seeds. On the other hand if the germination percentage calculated through the assumption of an error-free seed placement compares with the germination percentage obtained from the known seed number, the assumption would have a reasonable chance of being correct. This study was undertaken to serve this purpose. Coated seeds were used as a matter of convenience. Unfortunately, however, the sudden spell of inclement weather did not permit the verification of the main objective. Comparison of RER values (Table 1) show that hand seeded coated seeds germinated at a faster rate, thus giving a maximum germination percentage at an earlier date, than machine seeding. It is not certain if this resulted from the fact that pellet drilling pushed the seeds farther into the soil than hand seeding did.

B. LABORATORY STUDY ON SEED GERMINATION AND SEEDLING DEVELOPMENT

This aspect of tobacc research was carried out under several categories as described below.

Solid State Cooled Thermogradient Incubator:

A thermogradient seed incubator having an electrically heated upper surface and a thermoelectrically cooled lower surface was built and tested. Four thermoelectric modules were used, each having a cooling capacity of 10 to 50 watts at a cold surface temperature of 10 C with an input of 8 to 12 volts d.c. and a heat sink temperature of 25 to 50 C. The incubator consisted of a rectangular aluminum box 10.8 cm wide, 44.5 cm high and 35.6 cm long covered with 5 cm of styrofoam and 1.9 cm of plywood and fitted with twelve shelves. Temperature gradient was linear across the shelves and the increment between shelves could be varied from 1.2 C to 4.2 C. The coldest (bottom) shelf temperature could be controlled from 5 C to 24 C and the top (hottest) from 18 C to 54 C. Steady-state control over 24 hours had a standard deviation of 0.19 to 0.28 C.

Seed Metabolism: Temporal changes during tobacco seed germination are under investigation to develop a better understanding of the mechanism and regulation of gene regulation during germination and seedling development. An important aspect of this investigation is development of appropriate analytical techniques. Research during 1986 was directed toward a quick method of chlorophyll extraction and quantitation. Several methods available in the literature were compared for this purpose, and a DMSO (Dimethylsulfoxide) was developed therefrom. This new technique permits chlorophyll extraction and quantitation in about half the time as compared to the conventional acetone extration method. Further, it also makes the handling of acetone, a flamable liquid and suspected carcinogen, unnecessary. Development of a starch extraction method was also initiated during 1986 and is in progress. These results will be reported next year.

Autotrophic Transition: Cotyledons are the first photosynthetic organs of the tobacco seedling. But they share this function with the foliage leaves until their senescence and death. The relative importance of cotyledonary physiology during autotrophic transition was studied during 1986. The fact that cotyledons had higher fresh weight and dry weight per unit area than the foliage leaves suggests that cotyledonary photosynthesis plays a major role in seedling survival even after the appearance of the foliage leaves. This conclusion was supported by data on respiration, photosynthesis, and dry matter accumulation.

Stress Physiology: Tobacco seedlings experience thermal stress under solid and perforated plastic covers used for plantbed management. In view of the fact that several agrichemicals are believed to provide protection against several environmental and biological stresses, two chemicals, SN-7 and TDF, were investigated with respect to their effect on tobacco seed germination and early seedling growth. SN-7 was found to be a more effective chemcal than TDF, but both caused growth retardation at concentrations tested. This study will be continued with the use of other concentrations.

C. GREENHOUSE PRODUCTION OF TOBACCO TRANSPLANTS

In view of the fact North Carolina farmers are showing an increasing interest in this facet of tranplant production, research during 1986 was conducted with special emphasis on the Speedling floating system. A floating system has been developed with specifications shown in Fig. 1. The speedling system involves labor in transplanting small plugs from one tray to another, and again in feeding transplants from the second tray to the transplanter. Our effort is to avoid this labor requirement, and the expandable, honey-comb trays seem to hold promise for this purpose. At present study is in progress on plant growth response to various management procedures. These results will be reported next year.

II. GRADUATE STUDENTS: None

III. POSTDOCTORAL FELLOW: None

IV. PUBLICATIONS

1. Mohapatra, S.C., and W.H. Johnson. A thermogradient incubator for seed germination studies. Agron. J. 78: 351-356.

2. Mohapatra, S.C, J. Arcila, and H.W. Spurr, Jr. Effect of tobacco seed disinfection on germination and protein synthesis. Tob. Sci. 30: 66-68.

V. MANUSCRIPTS ACCEPTED FOR PUBLICATION

1. Mohapatra, S.C., and H.E. Pattee. Correlative light and scanning electron microscopy of thin sections and isolated cells. In "Correlative Microscopy in Biology", (M.A. Hayat, Ed.), Academic Press (In press).

2. Mohapatra, S.C., Arcila, J., W.H. Johnson, and L.A. Nelson. Induction of tobacco seed germination synchrony through dark preincubation treatment. Agron. J. 79 (In Press).

VI. MANUSCRIPTS IN REVIEW:

1. Suggs, C.W., S.C. Mohapatra, and H.B. Peel. Solid state controlled thermogradient incubator. Trans. ASAE (In Review).

2. Suggs, C.W., and S.C. Mohapatra. Tobacco transplants. 1. Effect of plant size on yield, value, chemistry and growth. Tob. Sci (In Review).

3. Suggs, C.W., and S.C. Mohapatra. Tobacco Transplants. 2. Effect of bareroot and intact seedlings on yield, value, chemistry and growth. (In Campus Review).

VII. PAPERS PRESENTED AT PROFESSIONAL MEETINGS

1. Mohapatra, S.C. Comparative physiology of cotyledonary and foliage leaves during autotrophic transition. Plant Physiol. 80(S): 30.

2. Mohanty, B., and S.C. Mohapatra. Developmetnal changes in foliar oxidases in *Nicotiana tabacum*. Plant Physiol. 80(S): 32

3. Suggs, C.W., and S.C. Mohapatra. Progressive moisture and dry matter loss of tobacco during cruring. ASAE Summer Meeting, San Luis Obispo, CA, June 29- July 2, 1986, Paper No. 86-3055.

4. Mohanty, B., and S.C. Mohapatra. Comparasion of biochemical and biochemical properties of four grades of flue-cured tobacco. Proceedings, 40th Tobacco Chemists Research Conference, Oct. 13-16, Knoxville, TN, pp.14.

5. Mohapatra, S.C., and C.F. Abrams, Jr. Effect of microwave drying on tobacco leaf constituents. Proceedings, 40th Tobacco Chemists Research Conference, Oct. 13 16, 1986, Knoxville, TN, pp.16.

6. Mohapatra, S.C., and C.W. Suggs. Seedling production: update and overview, 32nd Tob. Work. Conf., Baltimore, MD, Jan. 12-15, 1987.

7. Suggs, C.W., and S.C. Mohapatra, and H.B. Peel. Thermogradient seed incubator with solid state cooling. 32nd Tob. Work. Conf., Barltimore, MD, Jan. 12-15, 1987.

8. Suggs, C.W., and D.L. Eddington. Automatic feeding transplanter. 32nd Tob. Work. Conf., Baltimore, MD, Jan. 12-15, 1987

9. Mohapatra, S.C, and C.W. Suggs. Effect of stress protectants on tobacco seed germination and seedling development. 32nd Tob. Work. Conf., Baltimore, MD, Jan. 12-15, 1987

VIII. <u>GRADUATE STUDENT THESES COMPLETED</u>: NONE

IX. ACKNOWLEDGEMENTS:

Research on field experiments and greenhouse production was funded by Philip Morris USA. Research on stress physiology was funded by the Tobacco Foundation of NC. Technical assistance was provided by Hilton Peel, Timothy Seaboch, Don Eddington, Stanley Leary, and Valsa Samuels. Secretarial assistance was provided by Brenda Mason and Sandy Robinson.

Table 1. Effect of seed treatments on field performance of Speight G-28 tobacco seeds.

Table 1. Effect of seed treatments on field performance of Speight G-28 tobacco seeds.

		Weeks From Seeding									
		1	2	3	4	5	6	9	10		
Study #	Treatment	Average Seedling Number a/								MGP	RER b/
3	Control	0	0.2	2.0	6.3	6.7	6.5	9.3	10.0*	37.1	3.7
	RS-Treat	0	0	1.0	5.7	8.0	13.3*	12.5	12.3	46.3	8.2
	DPI	1.5	10.8	11.8	19.5	19.3*	12.0	10.5	14.0	72.2	18.1
4	Control	0	1.7	3.5	8.9	12.1*	10.8	7.8	10.8	44.8	9.0
	DPI	1.8	11.3	13.7	14.8	11.1	7.6	3.9	9.1	54.8	13.7
5	Control	0	0	0	4.3	19.5	15.0	17.5	20.5*	75.9	7.6
	24H	0	0	0.5	14.8	22.2	17.2	24.5*	20.3	82.2	10.1
	48H	0	0	4.7	19.0	16.7	19.7*	17.5	17.5	73.0	12.2
	72H	0	2.8	16.8	21.8	26.5*	21.5	21.8	22.3	98.2	19.6
	96H	1.8	10.5	21.2*	18.8	19.7	19.3	20.2	20.1	78.5	26.2
6	Hand Seeded	5.2	16.8	21.2	15.9	17.3	13.4	8.8	9.1	77.8	26.2
	Machine Seeded	2.2	8.0	8.0	10.5	15.6	14.0	10.4	8.1	57.8	11.6

* These seedling numbers are used to calculate maximum germination percentage (MGP).

a/ Average of 4-12 replicates depending on Study #.

b/ RER (Relative Emergence Rate) was calculated by dividing the MGM by the corresponding weeks from seeding.

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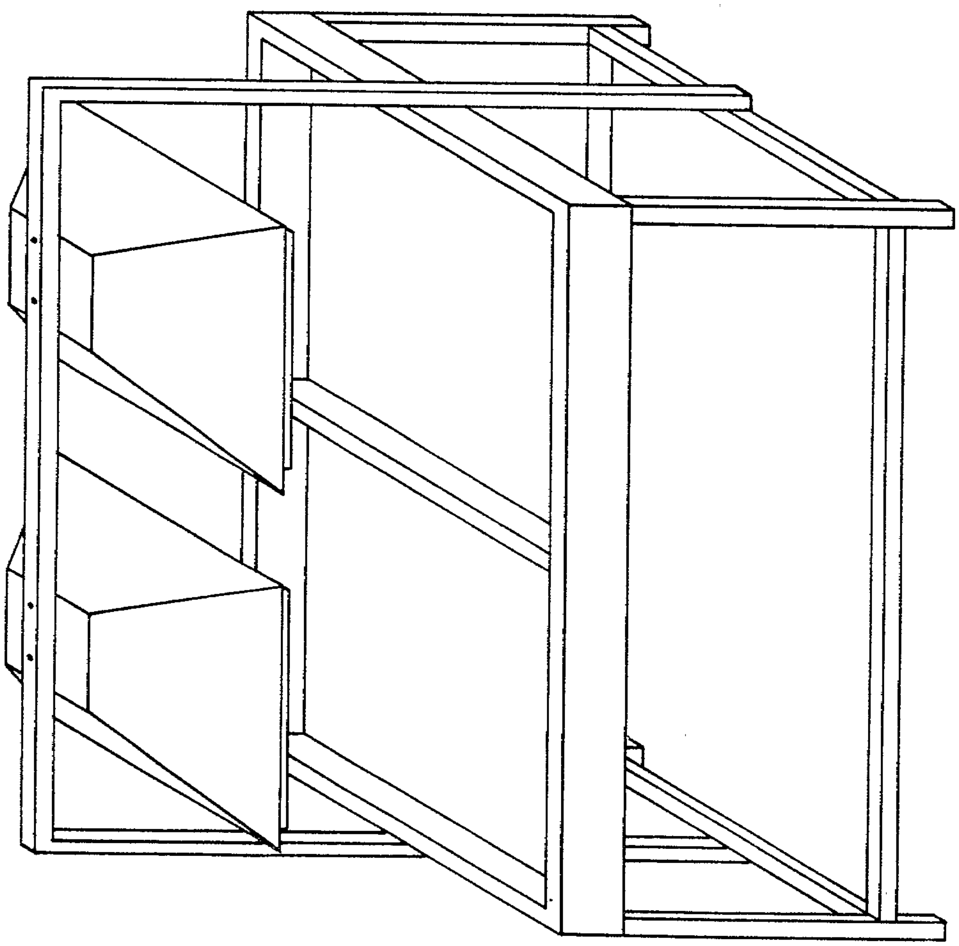

Fig. 1. THE FLOAT SYSTEM

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Title: NC 03804 Mechanization of Tobacco Production

Project Leaders: C.W. Suggs and R.W. Watkins

I. Summary of Research:

A. Effects of Tobacco Ripeness at Harvest on Yield, Value, Leaf Chemistry and Curing Barn Utilization.

Bright-leaf tobacco has traditionally been harvested at weekly intervals and estimates of optimum ripeness have been narrow. Attitudes toward nonoptimum harvest suggest that crop value decreases rapidly with harvest delay or preoptimum harvest.

Eleven years of data revealed that yield (kg/ha) peaked when the crop was harvested about one week before what is normally considered to be optimum ripeness and decreased slightly for two-weeks pre-optimum harvest and appreciably for three-and four-weeks post-optimum harvest. Price ($/kg) and grade index increased with ripeness to the one-week post-optimum harvest and then leveled off. Crop value ($/ha) was highest for the one-week pre-optimum harvest, decreased slightly for the optimal and one-week post-optimal harvest and appreciably for the three- and four-weeks post-optional harvest.

Addition of an pre-or post-optimum harvested crop, which could be cured before or after the main crop or when it was not fully utilizing the barns, allowed the curing barn fixed costs to be spread over a larger base. Savings in barn fixed costs more than compensated for the reduction in value due to non-optimum harvest for schedule strategies involving one-third hectare of 2-week green harvest for each hectare of optimally ripe harvest or one-third hectare of 1-week green for each hectare of one-week overripe harvest.

It can be concluded from this study that flue-cured tobacco can be harvested over a ripeness range several weeks wide without significant economic penalty. Increased curing barn utilization may more than compensate for the observed decrease in crop value due to pre- and post-optimum harvesting.

B. Self-Feeding Transplanter for Tobacco and Vegetable Crops.

Two proprietary transplanters, self-feeding from intact-root plants in a strand of paper cells, were evaluated along with a bare-root transplanter designed and constructed by the author. The bare-root transplanter used plants from a special digger which sewed through the leaves to form a continuous strand. One of the proprietary machines gripped plants between pairs of hands which then rotated, ferris wheel fashion, into the furrow and released the plant. It operated well at speeds up to about 100 plants/min. The other proprietary machine fed the strand of plants between a pair of feed rollers into a rapidly rotating pair of accelerator rollers which broke the strand between plants and propelled the plant into the drop tube. It operated well at speeds up to 140 plants/min except for some blockage in the drop tube. The author's bare-root machine fed plants between vee-belts past a microswitch which controlled the operation of the strand cutter and ejection of the plant into the furrow. It operated at speeds up to 43 plants/min but performance

Fig. 1. THE FLOAT SYSTEM

was only about 70%. The intact-root machines performed well but the bare-root transplanter uses plants from field beds which are less expensive and require less management than the greenhouses used to produce the intact-root plants.

C. Development of a Wireless Controller for a Tobacco Rack Hoist

In many hoist operations, for example, lifting racks of tobacco into a curing barn, a single operator tries to guide the load to the proper height and position it while controlling the motion by means of a switch on a multiconductor cable which is apt to get tangled with the lift chain and load. A simple wireless controller has been developed which gives precision height control, eliminates the control cable and allows the operator to stand clear of the chain and load. The controller consists of a 310 MHz hand-held transmitter which transmits a separate code depending on which of three function switches is pressed (up, down, stop). Codes are received and fed into a series of three decoders; one for each of the three codes transmitted. One of the decoders will recognize the signal and actuate the appropriate switch in the hoist. Modifications made in the hoist control circuit consisted of the addition of a switch driven laterally by a ball nut and shaft and a series of three trip blocks to stop the hoist at any one of three preselected heights. All of the original capabilities of the hoist were retained. The wireless controller performed according to design expectations and lift height precision was within about 3 mm (1/8 in).

II. Graduate Students:

Donald Eddington, working toward Ph.D. in transplanting area.
Liang Zhu, working toward MS in mechanization.

IV. Publications:

Suggs, C.W. and H.B. Peel. 1986. Speed Control for Hydraulically Powered Outboard Wheel. Applied Engr. in Agri. 2(2):82-84.

Suggs, C.W. 1986. Burley Mechanization Part 1. Effects of Various Amounts of Priming on Yield, Price, Value and Leaf Chemistry. Tob. Sci. 30:62-65.

Suggs, C.W., P.E. Harris and H.B. Peel. 1986. Development of a Wireless Controller for an Electric Hoist. Applied Engr. in Agri. 2(2):225-227.

V. Manuscripts Accepted for Publication:

Suggs, C.W. Bright Leaf Tobacco Harvest Schedule: Effects on Yield and Value. Accepted by Tob. Sci.

VI. Manuscripts in Review:

Self Feeding Transplanter for Tobacco and Vegetable Crops. Submitted to Trans. of ASAE.

VII. Papers Presented at Professional Meetings:

(1) Tobacco Mechanization, Presented at "Agritab" Conference, Oct. 3, 1986 at Cittade Castello, Italy.

(2) Self-Feeding Transplanter for Tobacco and Vegetable Crops. Summer Meeting of ASAE.

(3) Automatic Feeding Transplanter. Tobacco Workers Conf.

(4) Effects of Harvest Schedule on Yield, Price and Value. Tob. Workers Conf.

IX. Acknowledgements:

Research conducted during the reporting period was partially funded by a grant from Philip Morris, USA, Richmond, VA and R.J. Reynolds Company, Winston Salem, N.C. Technical assistance was provided by Hilton Peel, Tim Seaboch, S.M. Leary, Sidney Bland, Linda Blalock and Bill Lelekas.

Title: NC 03804 Mechanization of Tobacco Production

Project Leaders: Rupert Watkins and C. W. Suggs

I. Summary of Research:

Objective

The objective of this study was to determine the effect of various drying humidities on final apparent leaf quality. Previous tests had shown a range of humidities as acceptable for proper curing. The purpose of this study was to compare the effect of humidities within the accepted range.

Procedure

Tobacco grown under typical farm cultural practices was harvested by hand in a normal harvesting sequence for this study. The tobacco was bulk cured in small tightly constructed "test" barns equipped for automatic temperature and humidity control. These test barns had a capacity of 18 standard bulk racks providing two sales samples or "sheets" of tobacco per barn load. Six barns were used providing two barns for each of three humidities chosen for testing. Seven cures or "primings" were conducted. In all cures the tobacco was subjected to a normal yellowing environment of 37.7°C dry bulb temperature and 35°C wet bulb temperature for a period of 48 hours to 72 hours. When yellowing was adjudged complete in the six barns of the cure, the three test humidities were established in two barns each and maintained until the leaf was considered "dry" in all six barns. At the end of leaf drying, the dampers were closed for final stem drying.

The tobacco was "ordered" by flushing the barns with fresh air overnight. All barns of a given priming were flushed or ordered the same number of hours and all were unloaded on the same morning within one hour. Each of the twelve sheets from a given cure was tagged for proper identification, stored temporarily in the same pack house, and sold on the same warehouse floor the same day.

The wet bulb temperatures for the three humidities chosen for testing were: 35°C, 37.7°C, and 40.5°C. It was reasoned in advance that the higher humidity might produce a more orange color while the lower humidity might produce a brighter leaf.

Results

The sales prices received for the seven cures of three humidities each are shown in Table 1.

Table 1. Sales prices Received ($ per pound)

Cure No.	35°C Wet bulb	37.7°C Wet bulbs	40.5°C Wet bulb
1	1.37	1.35	1.35
2	1.44	1.44	1.44
3	1.55	1.55	1.55
4	1.66	1.63	1.67
5	1.59	1.63	1.69
6	1.66	1.70	1.60
7	1.53	1.54	1.53
Average	1.5429	1.5486	1.5471

The expected color differences were not reflected in the sales receipts. Differences were thought to be observed by the researcher, but if indeed they were real, they were not variant enough to fetch a significantly different price.

IV. Publications:

Watkins, R. W., Mechanization, Tobacco Information, 1987, AG187 NC AES, pp 102-111

VII. Papers Presented at Professional Meetings:

Curing Humidity and Leaf Quality. 32nd Tobacco Workers Conference. Baltimore, MD. January, 1987.

Title: NC 02136 Optimization of Tobacco Curing Systems

Project Leaders: Frank Abrams and Rupert Watkins

I. Summary of Research:

This research was conducted in cooperation with Dr. Willard W. Weeks and had the following objectives:

A. To evaluate the leaf chemistry of tobacco cured with drastically different drying rates.

B. To evaluate the apparent quality of tobacco cured with drastically different drying rates.

Procedure

Tobacco grown under normal cultural practices at the Oxford Tobacco Research Station, was hand-harvested and placed in bulk-racks in a normal harvest schedule and manner. The tobacco was cured in small (6 rack capacity) bulk curing units on the Oxford Station. Three units were loaded for each test or priming. Five primings or tests were conducted.

In each test, normal yellowing conditions of 37.7°C d.b. and 35°C w.b. were used for all three barns. When yellowing was adjudged complete, three drastically different drying schedules were imposed. On one barn the thermostat (d.b. temperature) was set at 71.1°C; on another the thermostat (d.b. temperature) was set at 54.4°C; and on the other the thermostat (d.b. temperature) was kept at 37.7°C. The thermostats (w.b. temperature) controlling the damper motors were left at 35°C throughout the drying schedules of all three barns. When the tobacco was deemed "killed out" in any barn, the heat was turned off and the tobacco subsequently "ordered" and removed from the barn.

Upon removal from the barn, each rack of tobacco was labeled and bundled separately for storage and subsequent grading and sampling. After samples were taken for Dr. Willard Weeks' chemical analysis, each "bundle" or rack of tobacco was graded by an official government grader. After grading, the tobacco was released to station personnel for subsequent sale on the open market.

Results

Average support prices (based on the government grades assigned to each of the six racks in each barn) for each barn of tobacco are shown in Table I. The differences between treatments may have been larger on average commercial farms where curing boxes or larger racks are used and where loading uniformity is probably not as good as on this research station.

Table 1. Average Support Prices for Tobacco Cured With Different Final Drying Temperatures

Priming No.	Maximum Drying Temperature 71.1°C	54.4°C	37.7°C
1	$1.23	$1.28	$1.17
2	1.35	1.33	1.43
3	1.63	1.63	1.59
4	1.44	1.57	1.46
5	1.36	1.61	1.63
Average	$1.40	$1.48	$1.46

The drying times required for the three treatments are shown in Table 2. The yellowing times of 2 to 3 days would be added to these time requirements to get the total curing time.

Table 2. Time Required for Leaf and Stem Drying at Different Temperatures

Curing No.	Drying Time (hrs.) 71.1°C	54.4°C	37.7°C
1	34	92	357
2	46	56	382
3	58	99	430
4	43	96	412
5	48	93	524
Average	46	87	421

Title: NC02136: Optimization of Tobacco Curing Systems

Project Leaders: C.F. Abrams, Jr., C.W. Suggs, S.C. Mohapatra

I. Summary of Research:

A. Particle Curing of Flue-Cured Tobacco

Reducing the size of fresh tobacco pieces to less-than-whole leaf sizes is under study because the resulting material can be handled more easily in mechanized methods, and because curing efficiencies may be improved by curing separately those pieces containing midrib from those pieces containing little or no midrib.

Work undertaken in the 1985-86 season was basically replicated in the 1986-87 season. The treatments are summarized in Table A-1. General crop flue-cured tobacco produced at the Oxford Tobacco Research Station was used in the study, and all curing experimentation was carried out at that site. Leaf tip particles, which were cut from the tip 2/3 of the leaf, contained relatively little midrib while stem particles, which were cut from the butt 1/3 of the leaf, had relatively high midrib content. Mixed particles were cut from whole leaves. The material was cut into approximately 76 mm x 127 mm particles. Treatments were included in which the midrib was crushed in mixed particles. The material was placed in curing cages at three initial density levels. The cages were 1.32 m x .78 m x .28 m, and they were filled with the 1.32 m x .78 m side down. To cure them they were placed in curing chambers described in the 1985-86 report so that the 1.32 m x .28 m side was normal to the preferred direction of air flow. A normal curing schedule was used.

Significant treatment effects were found in cured weight yield, cured % alkaloids, energy per kg of cured weight and the market support price as adjudged by establishment of market grade (Table A-2). The leaf tip, mixed and crushed-mixed treatments tended to produce higher cured weight yield than the stem treatments, a result which is consistent with the fact that water loss accounts for a large part of the weight removed in curing and the stem has a higher inherent initial moisture content. The energy required per unit of usable cured weight was substantially higher for the stem treatments than for any other, again likely attributable to the relative moisture contents in stem and lamina. The stem material appears less valuable based on governmant grade related market support price.

Lower initial loading density tended to result in more favorable response on all factors, but few differences were significant.

Dry weight loss did not differ among treatments, but it was observed to be unusually high for all treatments as compared to the results from the previous year's work. Inferred metabolic energy was high also because of the high dry matter conversion, and thus the ratio of metabolic energy to energy supplied by the curing system was large.

Table A-1. Particle Curing Treatments

Treatment	Infeed material	Density Relative	Density kg/m^3
1	Mixed, whole leaf	High	243
2	Leaf tip 2/3	High	243
3	Stem 1/3	High	243
4	Crushed-mixed whole leaf	High	243
5	Mixed, whole leaf	Med	182
6	Leaf tip 2/3	Med	182
7	Stem 1/3	Med	182
8	Crushed-mixed whole leaf	Med	182
9	Mixed, whole leaf	Low	121
10	Leaf tip 2/3	Low	121
11	Stem 1/3	Low	121
12	Crushed-mixed whole leaf	Low	121

Table A-2. Particle Curing Results

Infeed	Initial density kg/m^3	Fresh wt. kg	Cured wt. kg	Cured wt. yield %	Dry wt. loss %	Cured sug. %	Cured alk. %	----Energy Values---- per cured wt. kwh/kg	per H_2O wt. kwh/kg	ratio metab./ curing %	Price $/kg
Mixed	243	70	6.2	9.1	47.6	7.5	2.14	12.0	1.2	34.1	3.38
	182	52	4.3	8.5	51.8	6.4	2.15	11.4	1.1	40.9	3.38
	121	35	3.3	9.6	44.6	6.3	2.34	11.0	1.2	33.9	3.37
Leaf tip	243	70	7.5	11.0	41.0	6.7	2.31	9.5	1.2	33.8	3.30
	182	52	5.6	10.8	43.9	7.0	2.51	9.5	1.1	36.2	3.43
	121	35	4.1	11.9	36.7	6.5	2.47	9.3	1.2	29.7	3.43
Stem	243	70	3.9	5.7	65.1	6.4	1.73	20.2	1.2	48.2	2.94
	182	52	3.4	6.7	54.5	6.3	1.56	16.4	1.2	36.5	2.96
	121	35	2.9	8.6	30.7	6.4	1.55	18.5	1.2	15.0	3.22
Crushed mixed	243	70	5.5	8.1	52.3	5.1	1.71	13.3	1.2	36.9	3.22
	182	52	4.6	8.9	47.7	5.9	2.00	11.4	1.2	34.5	3.20
	121	35	3.6	10.6	41.3	6.5	1.92	12.4	1.2	29.3	3.47
lsd95				3.5			.25	4.9			.30

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B. Fine Shredding of Fresh Flue-Cured Tobacco Prior to Curing

A logical extension of the particle curing work might be viewed as further reducing the particle size such that the material obtained at the end of curing was substantially of filler size. While there are many manufacturing considerations as yet to be considered which relate ascertaining quality, handling, blending, and storage, there is the potential of reducing curing energy costs, improving on-farm handling and storage characteristics, and increasing producer profitability.

Table B-1 summarizes the treatments in this study. Both whole leaf and half laminas (midrib removed) were used as infeed material for the shreding operation. Leaf was shredded fresh from the field as well as asfet having been yellowed. A reciprocating cutter designed for cutting cured leaf (borrowed from Dr. T. J. Sheets) was used to shred the leaf material. The results were compared with material which was normally cured (whole leaf and half laminas) and then shredded. Shredd size was approximately 1.6 mm. The material was placed into 13 cm x 15 cm x 30 cm deep curing modules by hand with care being exercised to distribute the material uniformly within the modules. Initial density varied from around 0.2 g/cm^3 to 0.4 g/cm^3. The modules were placed into laboratory curing chambers for curing under approximately normal conditions.

Table B-1. Fresh Shredding Treatments

No.	Material Shredded	Condition When Shredded
1	Whole leaf	Fresh
2	Whole leaf	Yellowed
3	Lamina	Fresh
4	Lamina	Yellowed
5	Whole leaf	Cured
6	Lamina	Cured

Cured weight yield and dry weight loss showed significant treatment effects. The higher cured weight yields were associated with treatments in which lamina were shredded, as can be seen from Figure B1. This result could be a reflection of the greater efficiency in cured weight production of stemless material. As can be seen in Figure B-2, the dry weight loss seemed to be higher in material which was shredding after having been yellowed than that which was shredded while fresh indicating that perhaps most of the dry matter loss occurs during yellowing while the leaf is relatively active biologically.

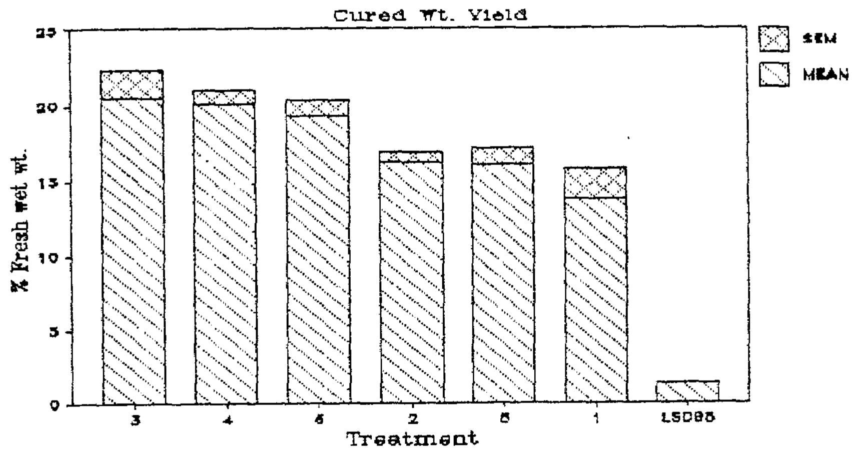

Figure B-1. Cured weight yield versus treatments.
1. Whole leaf, fresh shredded
2. Whole leaf, yellow shredded
3. Lamina, fresh shredded
4. Lamina, yellow shredded
5. Whole leaf, cured shredded
6. Lamina, cured shredded

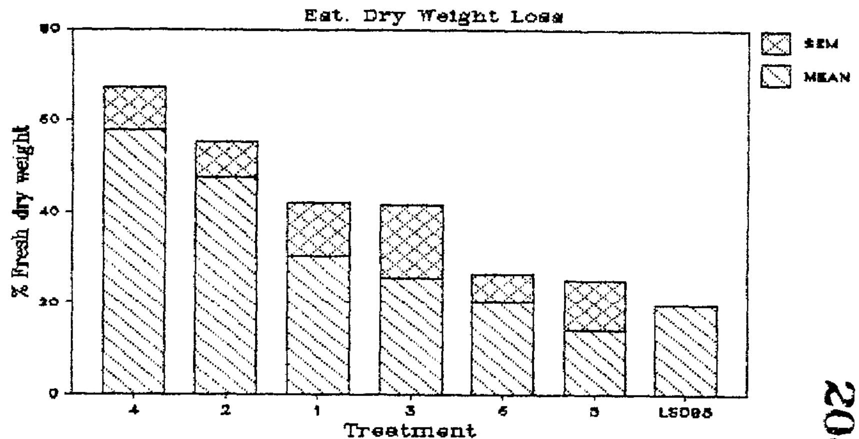

Figure B-2. Dry weight loss versus treatments.
1. Whole leaf, fresh shredded
2. Whole leaf, yellow shredded
3. Lamina, fresh shredded
4. Lamina, yellow shredded
5. Whole leaf, cured shredded
6. Lamina, cured shredded

C. Microwave Heating in Leaf Drying

A range of intensities and durations of microwave heating were investigated for heating yellowed flue-cured-type tobacco prior to drying, both under normal curing conditions and under natural air. A laboratory microwave oven was used to provide irradiation in the range of 0-750 w for durations of 0-60 s giving a range of treatment energies of 0 - 45000 W's. The treatments were applied to groups o sis yellowed 75mm diamater leaf disks.

The 60 s duration resulted in complete drying at the 750 W intensity while lower energy levels resulted in only partial drying of the sample leaf disks. It is treatment at these lower levels which is of particular interest. Estimation of chemistry by NIR did not reveal any significant differences among treatments, indicating that there may be a level of treatment for which natural air drying will produce an acceptable end product.

D. Effects of Leaf Curing Configuration and Bulk Density on Curing Characteristics

The curing characteristics of aligned and random bright leaf tobacco in racks and random leaf in boxes were evaluated in small (six rack capacity) barns over six harvests during 1984 and 1985. Energy requirements, excluding the fan, averaged 35 MJ/kg of cured tobacco, decreased for more densely loaded barns and was not significantly affected by curing configuration. Cured weight yield which averaged 16%, price and curing energy per unit of weight loss were not significantly affected by curing method.

Initial static pressure across the tobacco tended to be higher, flow lower, and flow resistance higher for the box than for the racks. Dry matter loss averaged 14.7% but was not significantly affected by curing method. The ratio of energy generated by leaf metabolism to energy supplied by the furnace was about 0.076 (7.6%) and was not significantly affected by curing method.

E. Dry Matter and Moisture Loss of Bright Leaf Tobacco During Curing

Average dry matter loss measured in four independent experiments ranged from 12.9% to 19.7% with the highest value being derived from short term respiration measurements. Many of the values fell in the 14.5% to 16.5% range. Although there was a trend for dry matter loss to be higher for the upper primings and for higher yellowing temperatures the differences were too small to be conclusive. Rate of moisture loss was approximately 15% per day throughout the six-day cure except for the last day when it decreased as the moisture in the leaf approached zero.

F. Correlation of Objective Measures of Tobacco Leaf Characteristics with Traditional Evaluations.

Studies in the previous year involved to the development of methodology for certain instrumental means of quality evaluation. This research was undertaken under the categories of Mechanical Properties, Structural and

Ultrastructural Properties, Biophysical Properties, Biochemical Properties, and Physiological Properties. The work reported here is companion to that done by Dr. Fred McClure with regard to optical properties.

1. Mechanical Properties of Cured Tobacco Leaf as Related to Body and Texture

Mechanical properties commonly dealt with by engineers in biological and non-biological problems relate to the manner in which materials act to resist deformation when exposed to external forces. The examination of the "elasticity" in a flue-cured tobacco leaf in a traditional grading sense involves manually stretching and flattening the leaf and observing its response, in which case the person conducting the grading operation applies an external force to the leaf and measures its response by visual and tactile observation. Likewise, making a judgement as to the body and surface texture of a leaf involves estimating its surface roughness, thickness, and mass. Certain well developed methods exist for instrumentally measuring these properties in various materials. The purpose of this continuing study is to exploit these methods to investigate their potential for supplementation of the process of tobacco quality determination where mechanical factors are concerned.

Work conducted during the 85-86 period with selected market grades of tobacco grown on the university research station indicated some potential for enhancement of the quality determination process by mechanical property measurement. Work undertaken during the 86-87 period was done using material supplied by the R. J. Reynolds Tobacco Company representing four classifications, which will be referred to as "grades", which span the quality range in use. Each grade was assigned an index. The grade descriptors and indices are given in Table F-1.

Table F-1. Sample industry grades

Sample Grades	
Descriptor	Assigned Index
SFQ	1
33X	2
#5	3
SLICK	4

The SFQ material is typical of very high quality leaf which is generally very costly and and not used extensively. The SLICK material is typical of very low quality material which is generally unacceptable for very extensive use. The 33X and #5 grades are typical of intermediate quality, extensively used material; the 33X material is generally perceived as being of higher quality than the #5 material. While these classifications may be applied to

tobacco having a range of market grades, the particular material used in this test was taken from marketing pile lots which had been assigned to these industry grades, but had not been mixed with other marketing pile lots. Accordingly, market grades can be made available for them.

Tests were undertaken to estimate the elastic and strength parameters, the dynamic vibratory characteristics, and the static friction properties of the sample material. In addition, thickness, mass, and moisture content was measured.

Leaves were selected from the sample material, and test pieces were cut from each leaf for each test from the mid-section of the leaf. Care was exercised to avoid major lateral veins in the test pieces which were cut with their long axes parallel to the midrib of the original leaf. The test pieces were placed in an environmentally-controlled chamber for 24 h for moisture equilibration, and all tests were conducted with test pieces having a moisture content in the range of 14 - 17 % wb. A total of 20 replications of each test was done, with one replication of each test being done on a test piece from each leaf.

The Strength & Elasticity Test was done by mounting a test piece between a movable crosshead and a fixed base so that movement of the crosshead tended to stretch the test piece in a direction parallel to its long axis. The deformation and the resulting force were recorded.

The Dynamic Vibration Response Test was conducted by mounting the test piece to a rigid base and stretching it with 30 g preload between the base and a vibration generator. The generator provided excitation which varied the tension of the sample in a vibratory manner. The analysis consisted on a single mode modal analysis which yielded a pole and residue from which the resonance frequency and damping factor were obtained.

The Friction Test used an inclined plane and the theory of static friction to determine the friction coefficient. An apparatus was constructed on which a weighted sample of leaf could be placed on a horizontal surface of stainless steel. As the surface was tilted, the angle of tilt at which sliding of the sample started was detected by a light activated digital reading of the voltage across a potentiometer coupled to the pivot shaft. The tangent of the angle at which sliding started is the static coefficient of friction.

Thickness was estimated by using a small micrometer to make 30 observations of leaf thickness on the swatch removed for obtaining test pieces. The thickness (t) of each test piece from each leaf was assumed to be the average of the 30 observations from that leaf.

Moisture content was measured for each test piece by weighing prior to the test, immediately after the test, and immediately after drying to constant weight in a microwave oven. The weight loss during the test was not found to be significant. (The protocol has been streamlined since 1985-86, reducing the testing time, so that testing in a specially conditioned chamber became unnecessary.) The moisture content (MC) of the test piece was then taken as the ratio of the difference in test weight and dry weight to the test weight

which gave the wet basis moisture content. Whenever the moisture content was found to be out of the 14-17 % range, the test was repeated with a new test piece cut from the swatch and reconditioned.

The values for the static elastic properties are given in Table F-2. The modulus of elasticity and strength appeared to offer the best means of differentiation of the grades from among all of the tests, and only those results are summarized here.

Table F-2. Values measured in the Strength and Elasticity Test.

		Observed Grade			
		SFQ	33X	#5	SLICK
Mod. Elasticity		227	169	205	154
kPa	StDev	123	62	81	34
Yield Strength		842	566	960	830
kPa	StDev	465	372	547	446
Ultimate Strength		1052	781	1030	898
kPa	StDev	372	316	546	373
Fracture Strength		672	500	683	717
kPa	StDev	328	197	447	418
Yield Strain		.606	.660	.630	.689
	StDev	.243	.260	.295	.187
Strain @ Ult. Str.		.785	.857	.782	.796
	StDev	.222	.238	.257	.228
Fracture Strain		1.530	1.598	1.578	1.596
	StDev	.100	.101	.096	.085
Thickness		1.386	1.563	1.511	1.469
mm	StDev	.231	.319	.308	.237
Moisture Content		15.3	16.0	15.8	16.0
%wb	StDev	1.0	1.0	1.0	.9

There appears to be evident a trend for the higher quality material to exhibit a higher modulus of elasticity while the yield strength tends towards the opposite trend. While neither of these trends is conclusively clear, they may be the basis for some grade separation. It is evident that the mechanism which tends to exhibit higher stiffness in the higher quality material does not impart higher strength to the material. A similar trend appears in the ultimate strength results, while the fracture strength and the strains do not show a discernable trend. It should also be noted that the highest quality material is somewhat thinner than the other grades.

The results of statistical modelling to generate a regression of grade index on the strength and elasticity parameters are shown in Figure F-1. The R^2 for this fully interacted model was .95 for this fully interacted model. It was found that MC and t had a significant effect in that when removed the R^2 decreased markedly. However, MC and t alone in a model did not produce reasonable prediction.

While there does not appear to be one simple mechanical property from among those tested which differentiates the grades clearly, a combination of several properties into a predicting regression does seem feasible.

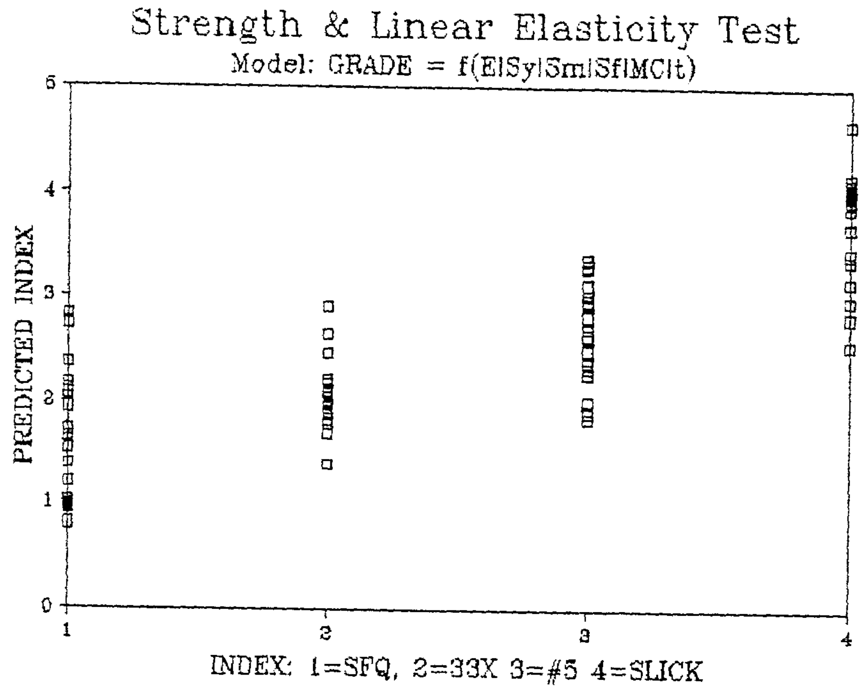

Figure F-1. Regression of grade index on strength and elasticity parameters.

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2. Biophysical Properties:

This study involved comparison of fluorescence, leaf-extract optical absorption, leachate conductivity and specific weight. Among these, leachate conductivity rate ranked the four grades in the following order with decreasing conductivity rate: SFQ > 33X > #5 SLICK. This pattern was observed (Figure F-2) with both 1985 and 1986 samples. It thus appears that leachate conductivity has the potential for use as a quantitative parameter for objective evaluation of tobacco quality. In view of the fact that the rate of leaching becomes nondiscrete after about 15 min, the leaching kinetics must be monitored for less than this duration. A limitation of the kinetic approach is the inability for simultaneous measurement of a large number of samples with one instrument. On the other hand, an increase in instrument number will add to the cost. This problem can be solved by substituting a static measurement method for the kinetic method. Thus, samples were kept in vial under stirring (a shaker is ideal for a large number of samples) for 10 min, following which the samples were separated from water and conductivity of the latter was measured. This way, any number of samples can be measured followed by storage of the leachate and measurement of their conductivity with one instrument over a period of time. As shown in Figure F-3, the static method also distinguished between the four grades in both years samples.

Specific weight (i.e. dry weight/cm^2) also appeared to have some value for objective evaluation of tobacco quality. This parameter distinguished the best grade (SFQ) from the rest but could not distinguish between the remaining grades (Figure F-4). Thus, specific weight may be of value when used in conjunction with one or more other parameters.

3. Biochemical Properties:

This involved the measurement of such chemical constituents as starch, sugar, alkaloids, polyphenol, amino acid, hexouronic acid, protein, soluble nucleotide, chlorophyll, glucose, sucrose, and the activities of several oxidative enzymes. Among the numerous constituents measured, only starch seemed to be significant for distinguishing the four grades and followed the following decreasing order: SLICK > #5 > 33X > SFQ (Figure. F-5). The reverse relationship between starch and leachate conductivity is noteworthy. This relationship is, however, expected because leachate conductivity reflects the solute (through charged) content, which comes in one way or another from the degradation of starch.

4. Microscopic Properties:

Light microscopic properties were reported last year. Investigations during 1986-1987 emphasized scanning electron microscopic (SEM) properties. Although certain structural differences were evident between the four grades, no systematic pattern has evolved yet. Therefore, further investigations will be conducted on this aspect. However, the subcellular packaging inside the SLICK grade was distinctly different from the rest of the grades, perhaps due to high starch content as mentioned above. An additional advantage of the SEM technique is that it permits accurate measurement of leaf thickness with

negligible artifacts. Figure F-6 compares the thickness values obtained manually with a micrometer and those obtained with the SEM. The micrometric method consisted of measuring the thickness of 10 layers of leaf with a micrometer and averaging the value therefrom. The micrometric values were not only much higher than the microscopic values, but were also higher for the dry leaves as compared to the damp samples. These discrepancies are expected in view of the fact that voids present between layers of leaves and the leaf surface and the micrometer influence the micrometric data, and these voids are greater between layers of dry leaves than damp leaves. The SEM method on the other hand is grossly inadequate, because at any given time it measures less than 0.001% of the leaf surface, or expensive if ideal sampling is done as shown in Figure F-7.

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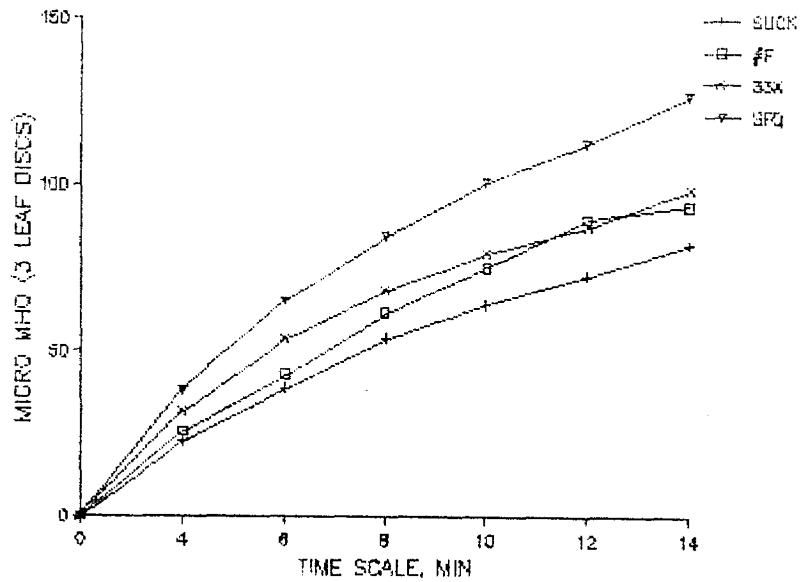

Figure F-2. Leaching Kinetics

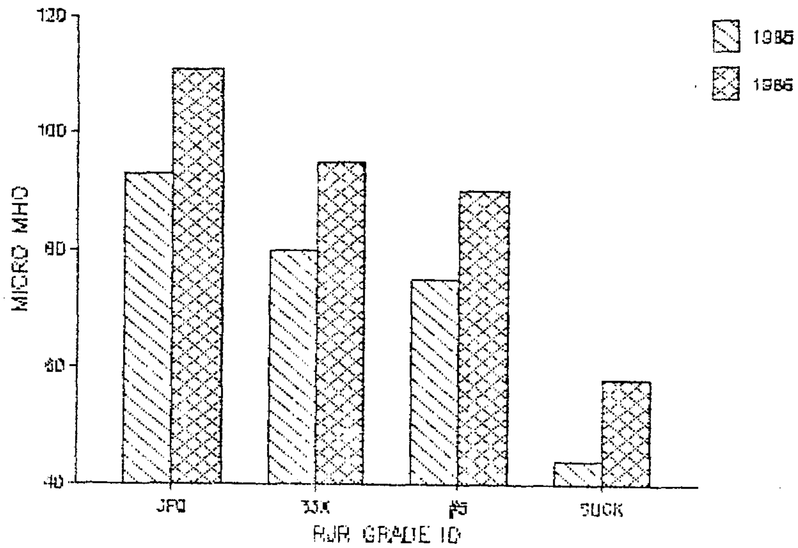

Figure F-3. Static Leachate Conductivity

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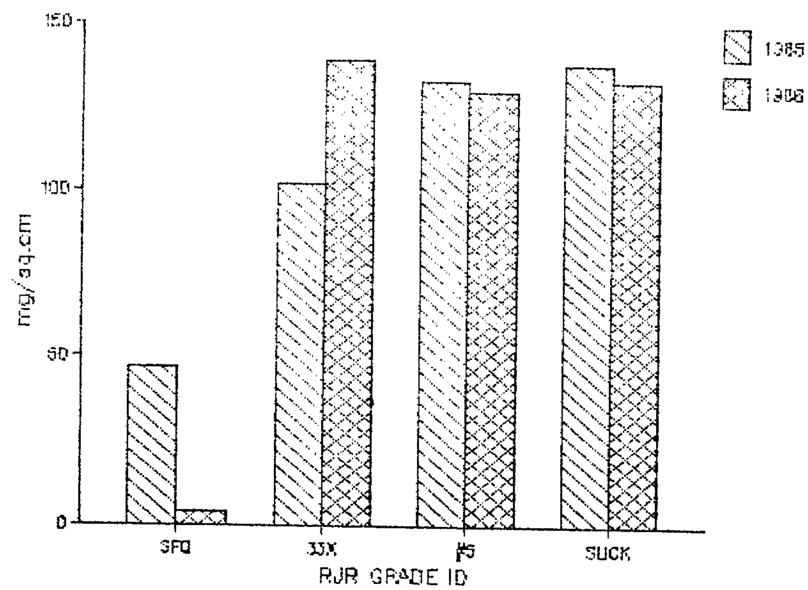

Figure F-4. Specific Weight

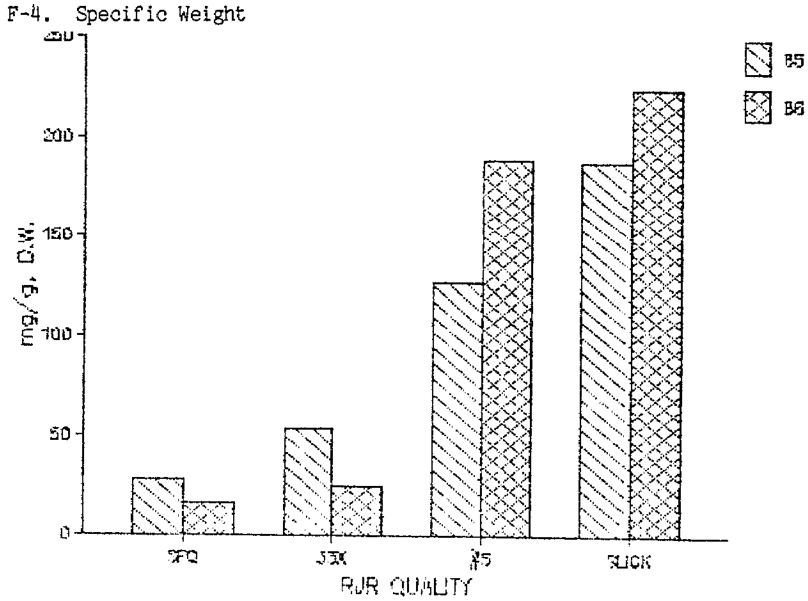

Figure F-5. Starch

THICKNESS, MICRO METER

Figure F-6.

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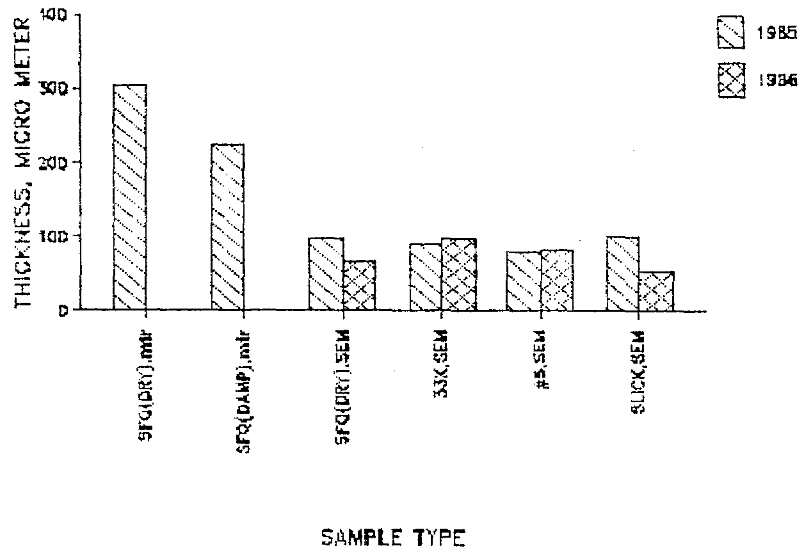

Figure F-6. Thickness Measurement.
Micrometric (mtr) vs microscopic (sem) methods.

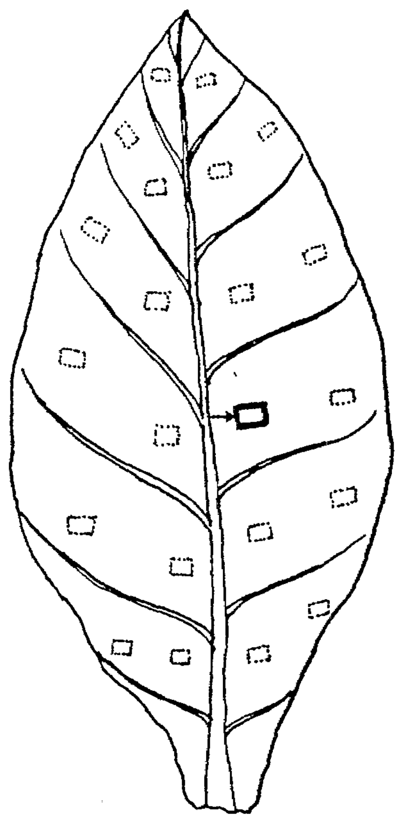

Figure F-7. Schematic of tobacco leaf showing sample collection locations for SEM thickness measurement. Dotted lines represent "ideal" sample collection sites. Solid lines represents "actual" site of collection.

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6. Phytotron Production of Tobacco:

In order for objective evaluation of tobacco quality to be successful, there needs to be a reliable source for reproducible and predictable tobacco quality. Because of the field variability, attempt was made to grow tobacco in the phytotron followed by curing and grading. Although the plants and the leaves therefrom had the field phenotype, their cured quality did not meet grading criteria. It is thus obvious that the phytotron cultural practices available for the production of tobacco with field phenotype does not assure the curability and the cured quality of the leaf, and that new cultural methods need to be developed to meet the latter objectives.

II. Graduate Student:

S. Sahi - Development Physiology of the Tobacco Leaf

III. Postdoctoral Fellow:

Dr. B. Mohanty - Ultrastructural and Chemical Characterization of Tobacco Quality.

IV. Publications:

Suggs, C. W., L. L. Blalock and H. B. Peel. 1986. Air Flow Through Fresh Tobacco Leaf Particles. Trans. of the ASAE 29(4):1156-1161.

V. Manuscripts Accepted for Publication:

Suggs, C. W., S. M. Leary and H. S. Bland. Effects of Leaf Curing Configuration and Bulk Density on Curring Characteristics. Accepted by Tobacco Science.

VI. Manuscripts In Review:

Suggs, C. W., and S. C. Mohapatra. Dry matter and moisture loss of bright leaf tobacco during curing.

VII. Papers Presented at Professional Meetings:

Abrams, C. F. Jr. and C. W. Suggs. Cut-Strip Curing of Flue-Cured Tobacco. 32nd Tobacco Workers Conference, January 12-15, 1987, Baltimore, MD.

Abrams, C. F. Jr., T. L. Foutz and C. W. Suggs. The Relation of Viscoelastic Properties of Flue-Cured Tobacco to Quality. 32nd Tobacco Workers Conference, January 12-15, 1987, Baltimore, MD.

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Abrams, C. F. Jr. Fresh Shredding of Flue-Cured Tobacco. 32nd Tobacco Workers Conference, January 12-15, 1987, Baltimore, MD.

Mohanty, B., and S. C. Mohapatra. Developmental changes in foliar oxidases in Nicotiana tabacum. Plant Physiol. 80(S):32.

Mohanty, B., and S. C. Mohapatra. Comparison of biochemical and biophysical properties of four grades of flue-cured tobacco. Proceedings, 40th Tobacco Chemists Research Conference, Oct. 13 - 16, Knoxville, TN, pp. 14.

Mohapatra, S. C., and C. F. Abrams, Jr. Effect of microwave drying on tobacco leaf constituents. Proceedings, 40th Tobacco Chemists Research Conference, Oct. 13-16, 1986, Knoxville, TN, pp.16.

Sahi, S. V., and S. C. Mohapatra. Effect of root removal and nutrition withdrawal on quality parameters of phytotron grown tobacco. 30th Tob. Work. Conf., Baltimore, MD, Jan. 12-15, 1987.

Suggs, C. S. and S. C. Mohapatra. Progressive Moisture and Dry Matter Loss of Tobacco During Curing. Paper No. 86-3055, ASAE Summer Meeting, June 29-July 2, 1986, California Polytechnic State University, San Luis Obispo, CA.

Suggs, C. W. and S. C. Mohapatra. Dry Matter Loss During Curing. C. W. Suggs and S. C. Mohapatra. 32nd Tobacco Workers Conference, January 12-15, 1987, Baltimore, MD.

Suggs, C. W., H. B. Peel and T. R. Seebach. Air Flow at Various Stages of Cure. 32nd Tobacco Workers Conference, January 12-15, 1987, Baltimore, MD.

VIII. Graduate Student Theses Completed During Reporting Period: None

IX. Acknowledgements:

The technical assistance of Hilton Peel, Sidney Bland, Stanley Leary, Valsa Samuels, Sudha Ramesh, Tim Foutz, James Gore, A. Lansari, Prem Singh, David Williams, Linda Blalock, Tina Brunner, Bradley Bennett, T. C. May, and the staff of the Biological and Agricultural Engineering Research and Electronics Shops supervised by Robert Gaines and Phil Harris, respectively, was essential to the execution of this research. Secretarial assistance was provided by Brenda Mason and Ann Griffin.

Research on quantitative evaluation of tobacco quality is supported by R. J. Reynolds Tobacco Company, Winston-Salem, NC.

NC 02124: INSTRUMENTATION AND PROCEDURES FOR MEASURING QUALITY AND COMPOSITION OF AGRICULTURAL PRODUCTS

PROJECT LEADER: W. F. McClure
Professor

I. Summary of Research:

A. Correlation of Optical Measurements of Tobacco Characteristics with Traditional Evaluations of Quality

INTRODUCTION

Research was continued during the above reporting period to test the feasibility of optical measurements to traditional evalutions of quality. Organized as six experiments, the work consisted of the following:

1. Wet Chemistry vs. Stalk Position
2. Determination of Stalk Position from Wet Chemistry
3. Determination of Stalk Position from NIR Spectra
4. Determination of Grade from NIR Spectra
5. Searching and Matching as a Method of Objectively Identifying Tobacco Types
6. Software Development Supporting This Work

WET CHEMISTRY VS. STALK POSITION

A total of 200 flue-cured samples, 50 from each of four stalk positions (1. lower, 2. low-middle, 3. upper-middle and 4. top), were analyzed in triplicate for nicotine, nitrogen, sugars, water soluble nitrogen, calcium and potassium. The triplicate analyses were averaged and the standard deviation within each stalk position was computed for each constituent. A plot of each constituent vs. stalk position is shown in Figures 1-6.

NICOTINE. Nicotine (Figure 1) increased nonlinearly from 1.14 to 3.46. This is similar to the spectral data set reported last year.

NITROGEN. Nitrogen (total nitrogen, Figure 5) increased from 1.94 to 2.42% (stalk positions 1-4). However, nitrogen did not increase from stalk positions 1 to 2.

SUGARS. Sugars (total reducing sugars), as seen in Figure 3) increased from stalk position 1 to stalk position 2, but continued to decrease from stalk position 2 to 3 and from 3 to 4. The average sugar value at each stalk position 1, 2, 3, 4 was 9.89, 17.64, 14.11 and 11.48% respectively.

WATER SOLUBLE NITROGEN. Water soluble nitrogen (Figure 4) showed the same general trend as total nitrogen. WSN increased from approximately 0.92

to 1.19% from stalk position 2 to stalk position 4 with a slight decrease from stalk position 1 to 2.

CALCIUM. Calcium (Figure 5) decreased from 2.76 to 1.56% from stalk position 1 to 2. However, there was little change thereafter except for a slight increase from stalk position 3 to 4.

POTASSIUM. Potassium (refer to Figure 6) decreased from 3.56% at stalk position 1 to 2.78% at stalk position 2; the level of potassium increased slightly from stalk position 2 to stalk position 4.

DETERMINING STALK POSITION FROM WET CHEMISTRY

From the empirical relationships established above, a multilinear model was developed of the form

$$SP = f(NIC, NIT, SUG, WSN, CAL, POT) \; . \; . \; . \; . \; . \; . \; . \quad [1]$$

to test the feasibility of determining stalk position from wet chemistry analyses. The coefficient of determination (r^2) for the linear model (illustrated in Figure 7) was 0.712. It is interesting to note the similarity between Figures 1 and 7. In the stepwise procedure NIC was included first in the model, followed by CAL, NIT, WSN, SUG and POT. Nicotine alone accounted for 64% of the correlation in the model, adding CAL and NIT improved the correlation by an additional 6% ($r^2 = 0.707$). WSN, SUG, and POT contributed essentially nothing to the model.

DETERMINING STALK POSITION FROM NEAR INFRARED REFLECTANCE

Figure 8 show the potential of using near infrared reflectance to determine the stalk position of tobacco. The coefficient of determination (r^2) for this set of 200 samples was 0.753% and a standard error of 1/2 stalk position. It is again noted in the plot in Figure 8 that there is a similarity of Figure 1, indicating that the instrument is actually zeroing in on the nicotine matix in the sample. If one considers the fact that nicotine can be easily measured using NIR (see Figure 9), the error associated with the measurements in Figure 8 are probably due to the subjective stalk position determinations. The data further suggest that, since traditional measures of quality are an attempt to judge the chemistry of the leaf, may be more appropriate to use near infrared reflectance to directly measure the chemistry of the leaf.

DETERMINING GRADE FROM NEAR-INFRARED REFLECTANCE

Twenty replications consisting of three leaf disks from each of four grades SFQ, 33X, #5 and Slick were run on the COMP/SPEC. Disks were not available on all samples so only 183 of a possible 240 samples gave useable spectra. Spectra from the three disks were averaged to give 61 spectra for correlating with grade. A multilinear model was fitted using the Fourier coefficients as the independent variables, or

$$\text{GRADE (by NIR)} = K_0 + K_1F_i + \ldots + K_7F_j$$

where

K_0 = intercept

$K_1 - K_7$ = regression coefficients

$F_i - F_j$ = Fourier coefficients with $i = j$

Figure 9 shows the relationship of NIR estimates of grade vs the subjective grade assigned to the samples. The coefficient of determination (R^2) was 0.745 with a standard error of 0.6 stalk position.

SPECTRAL SEARCHING AND MATCHING AS A METHOD OF OBJECTIVELY IDENTIFYING TOBACCO TYPES

Near-infrared spectra of 100 samples of tobacco from each tobacco-type, including flue-cured, dark-fired, Maryland and burley, were recorded on the COMP/SPEC. The Fourier (FO) coefficients, Fourier derivative (FOD1 and FOD2) coefficients and the power spectra were computed from the Log (1/R). A standard spectrum for each tobacco type was obtained by averaging the 100 spectra in each of the files.

A program (called SAM, Search And Match) was written to compute the dot product of unknown spectra with each of the standards and print out the cosine of the angle between the spectral vectors. The cosines, very much like correlation coefficients, become 1.0 with a match and -1.0 when the spectral vectors are totally unrelated.

Figure 10 shows a typical output from the search and match program. Sample #1 from the file D1MAR is compared to the standard file D1STD. The printout below indicates the sample is a Maryland type with a subsequent listing of the closest neighbor being burley, dark-fired and flue-cured respectively.

In order to get an appreciation of the accuracy of the search and match method, the standard file was run against 4 data files, one file each for the four types. Each of the check files contained approximately 100 samples. The results of this accuracy check is shown in Figure 11. Of the 4 data treatments (FO, D1, D2, AND PW), the D2 treatment gave the most consistent results. The FO and PW treatments gave the poorest results.

These results will have an impact on the development of intelligent machines, in the laboratory or on line, where operators will no longer need to recognize tobacco types. Consequently, tobaccos submitted to NIR based machines can identify the type, and automatically pull the "best" calibration to determine physical properties or chemistry.

DEVELOPMENT OF SOFTWARE

Software for analyzing the relationship of optical data to properties of tobacco was transferred and converted to run on the IBM PC/AT. The search and

match program (SAM) represents a breakthrough in developing intelligent aspects of NIR technology. Future NIR instruments will very likely employ this and other methodology for determining the "character of samples" submitted for analyses. Software was also developed (INSERT) which would allow the insertion of non-spectral data into multilinear models. This software will be useful in exploring the combination of the various measurements into one model describing traditional parameters of color, body and texture. Software for the determination of principle components in the spectral data was started and should be in operation for 1987-88.

II. Graduate Students:

1. Roger M. Hoy: Correlation of Optical Measurements of Tobacco Characteristics with Traditional Evaluations of Quality

2. M. Scott Howarth: Computer Vision Systems for Evaluating Quality Factors

III. Publications:

(1) McClure, W. F. 1986. Status of near-infrared technology in the tobacco industry. In "Recent Advances in Tobacco Science: Advances in the Analytical Methodology of Leaf and Smoke" (Eds. R. F. Severson, Dale E. Mathis, and Richard A. Manning) 12:3-53. 40th Tobacco Chemists' Research Conference, Knoxville, TN.
(2) Williamson, R. E. and W. F. McClure. 1986. Rapid spectrophotometric analysis of the chemical composition of tobacco. Part 4: Total Nitrogen. Tob. Sci. 30:109-111.
(3) McClure, W. F. and A. M. C. Davies. 1986. Fourier analysis of near-infrared spectra. In "Proceedings of the 1985 International Conference on Fourier and Computerized Infrared Spectroscopy". SPIE 553:256-257.
(4) Davies, A. M. C. and W. F. McClure. 1986. Prospects for process control using Fourier transformed near infrared data. In "Proceedings of the 1985 International Conference on Fourier and Computerized Infrared Spectroscopy". SPIE
(5) Davies, A. M. C. and W. F. McClure. 1985. Near Infrared Analysis of Foods. Analytical Proceedings(England) 22:321-322.
(6) Kano, Yoshio, W. F. McClure and R. W. Skaggs. 1985. A near infrared reflectance soil moisture meter. Trans. of the ASAE 28:1852-1855.

IV. Manuscripts in Review

(1) Whitaker, T. B., H. E. Pattee, W. F. McClure and James W. Dickens. 1986. Predicting peanut maturity using near infrared reflectance.
(2) Williamson, R. E., J. F. Chaplin and W. F. McClure. 1986. Near-infrared spectrophotometry of tobacco leaf for estimating tar yield of smoke.

V. Papers

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(3) Williamson, R. E., J. F. Chaplin and W. F. McClure. 1986. Near-infrared spectrophotometry of tobacco leaf for estimating total particulate matter yield of smoke.
(4) Gao, Wenyu and W.F. McClure. 1987. NIR analysis of the chemical composition of dark-fired tobacco.
(5) Gao, Wenyu and W.F. McClure. 1987. Near infrared reflectance analysis of minerals in tobacco.
(6) Gao, Wenyu and W.F. McClure. 1987. Design and development of an X-Y-Z robot.

V. Papers presented at professional meetings:

(1) McClure, W.F. 1986. Correlation transform spectroscopy in Fourier Space: Spectral searching and matching. Federation of Analytical Chemists and Spectroscopy Societies (FACSS), St. Louis, MO (September 26-October 3).
(2) McClure, W. F. 1986. Correlation transform spectroscopy: Derivative enhancements in Fourier Space. Federation of Analytical Chemists and Spectroscopy Societies, St. Louis, MO (September 26-October 3).
(3) McClure, W. F. 1986. Derivative enhancements in Fourier Space. The Rocky Mountain Conference on Analytical Chemistry and Spectroscopy, Denver, CO (August 4-7).
(4) McClure, W. F. 1986. Derivative enhancements in Fourier Space. The American Society of Agricultural Engineers, San Luis Obispo, CA (June 29-July 2).
(5) McClure, W. F. 1986. Development of Near-infrared Fourier Transform Spectroscopy. 6th Annual National Forage Network Workshop, Athens, GA (April 13-April 16).
(6) McClure, W. F. 1986. Nondestructive methods of evaluating agricultural products: possible applications to grapes. Viticultural Science Symposium. Florida A&M University, Tallahassee, Florida (June 12-13).
(7) McClure, W. F. 1986. The use of Fourier transforms in near-infrared spectroscopy. 3rd International Diffuse Reflectance Conference, Chambersburg, PA (August 17-22).
(8) McClure, W. F. and R. E. Williamson. 1986. Status of near-infrared technology in the tobacco industry. 40th Tobacco Chemists' Research Conference, Knoxville, TN (October 13-16).
(9) McClure, W. F. and R. E. Williamson. 1986. Electronic measurements of the quality and composition of tobacco. International Tobacco Exhibition Conference, Richmond, VA (September 16-18).
(10) McClure, W. F. and F. T. Jones. 1986. Near-infrared analysis of poultry feeds. Poultry Feeds Industry Analyses Symposium, NC State University, Raleigh, NC (July 16).
(11) McClure, W. F. 1986. Enhancement of near-infrared data using Fourier analysis. Technicon International NIRA Symposium. Tarrytown, NY (September 9-10).

VI. Graduate Student Theses Completed During Reporting Period:

Hoy, Roger M. 1986. Development of a Robotic Gripper for Handling Agricultural Products. Masters Thesis. North Carolina State University.

VII. Visiting Professionals:

Mr. Gao Wen-yu, Visiting Scholar. Huazhong Agricultural College, Wuhan, Peoples' Republic of China (2 years).

VIII. Acknowledgements:

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Appreciation is expressed for the continued support and encouragement of Dr. R. E. Williamson, USDA/ARS; Dr. W. W. Weeks, Crop Science Department and Dr. F. G. Giesbrecht, Statistics.

Special appreciation is given to Mr. Mike McLester, Electronic Technician for this technical support and encouragement over the years.

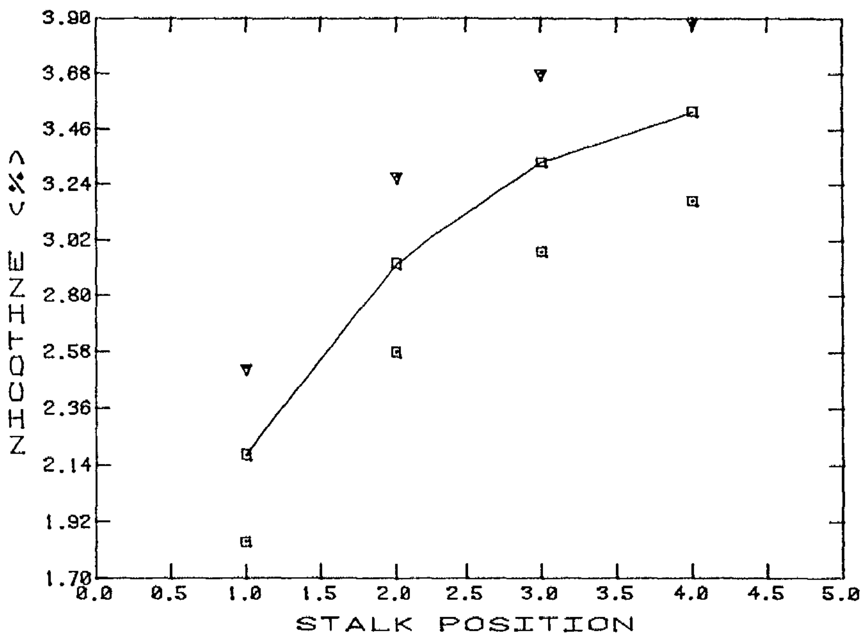

Figure 1. Relationship of wet-chemical analysis of nicotine to stalk position.

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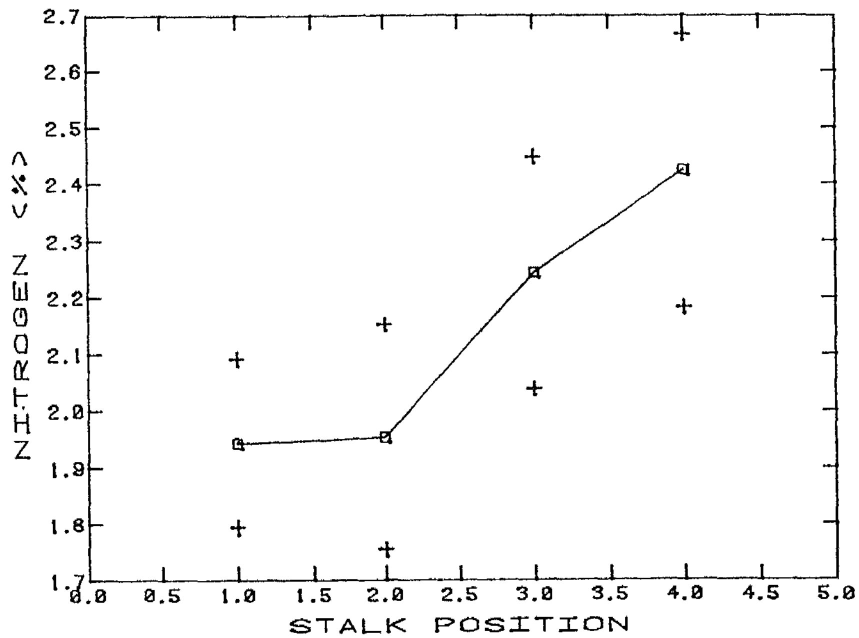

Figure 2. Relationship of wet-chemical analysis of nitrogen to stalk position.

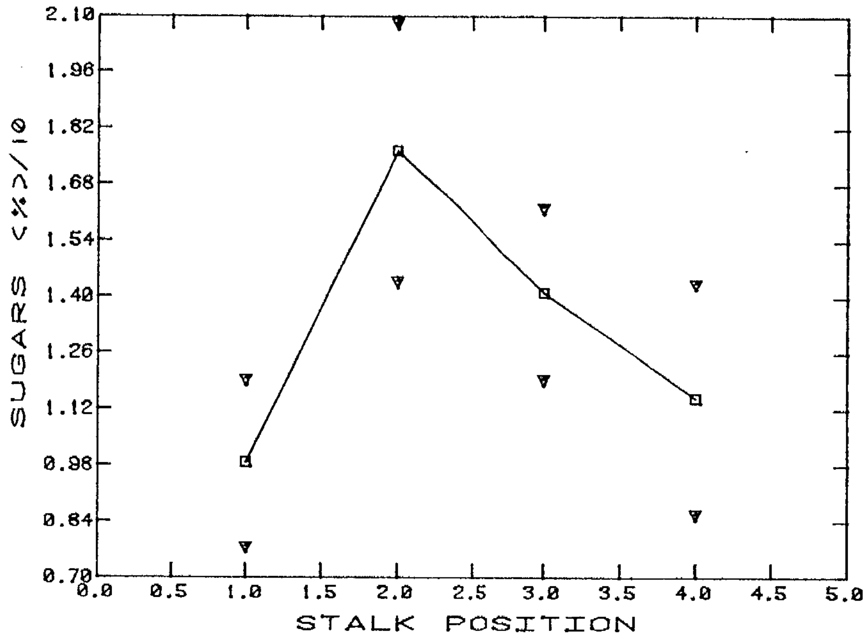

Figure 3. Relationship of wet-chemical analysis of sugars to stalk position.

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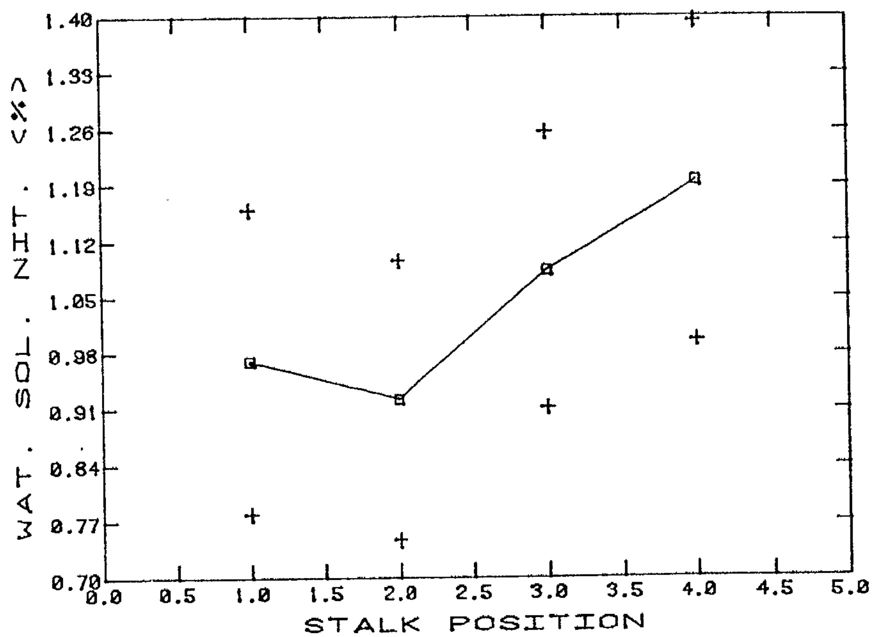

Figure 4. Relationship of wet-chemical analysis of water-soluble nitrogen to stalk position.

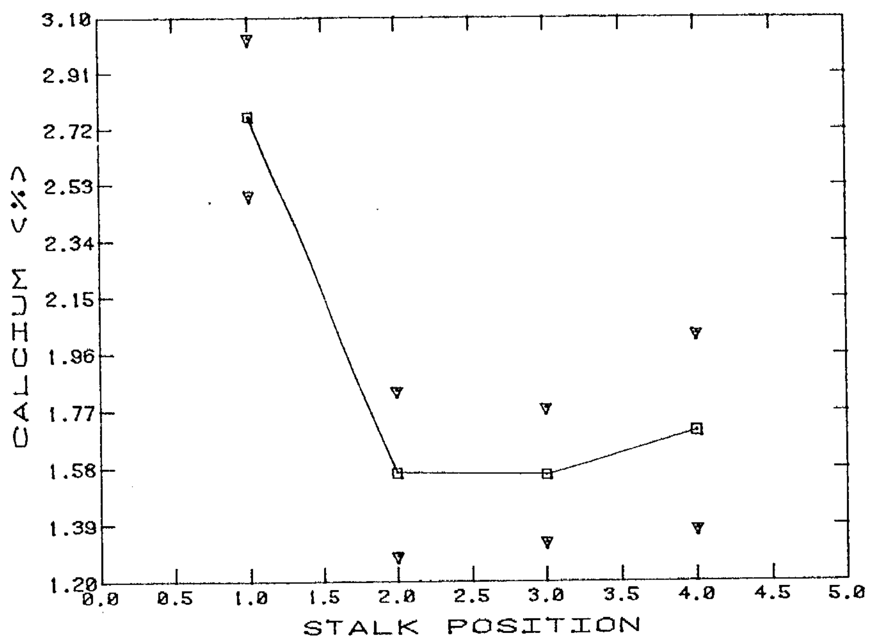

Figure 5. Relationship of wet-chemical analysis of calcium to stalk position.

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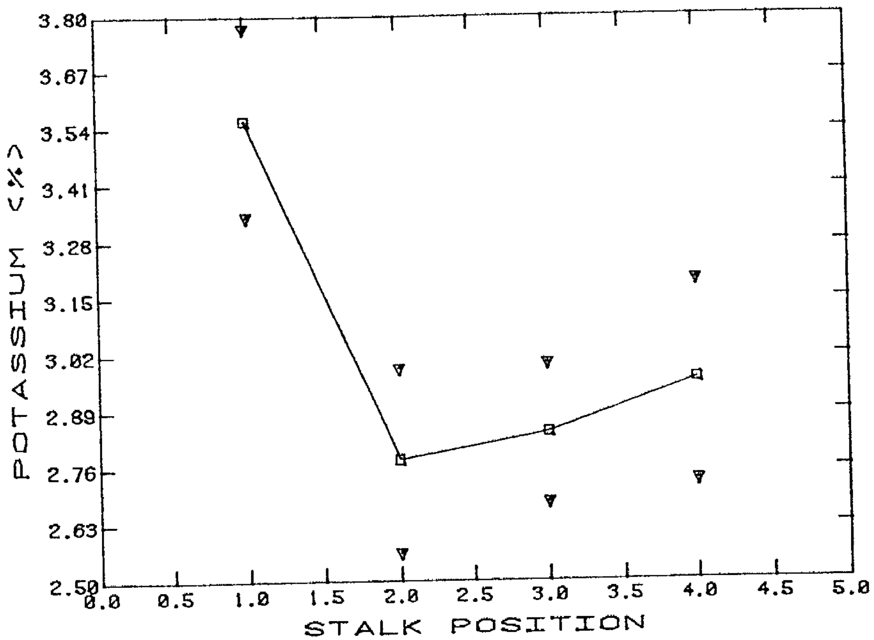

Figure 6. Relationship of wet-chemical analysis of potassium to stalk position.

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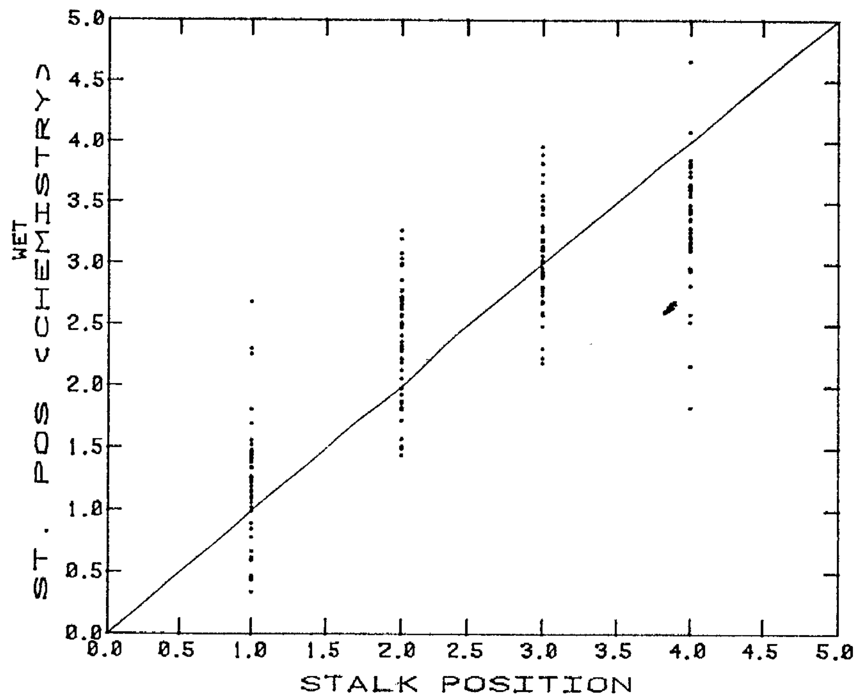

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Figure 7. Determining stalk position by a multilinear model with nicotine, nitrogen, sugars, water-soluble nitrogen, calcium and potassium as independent variables.

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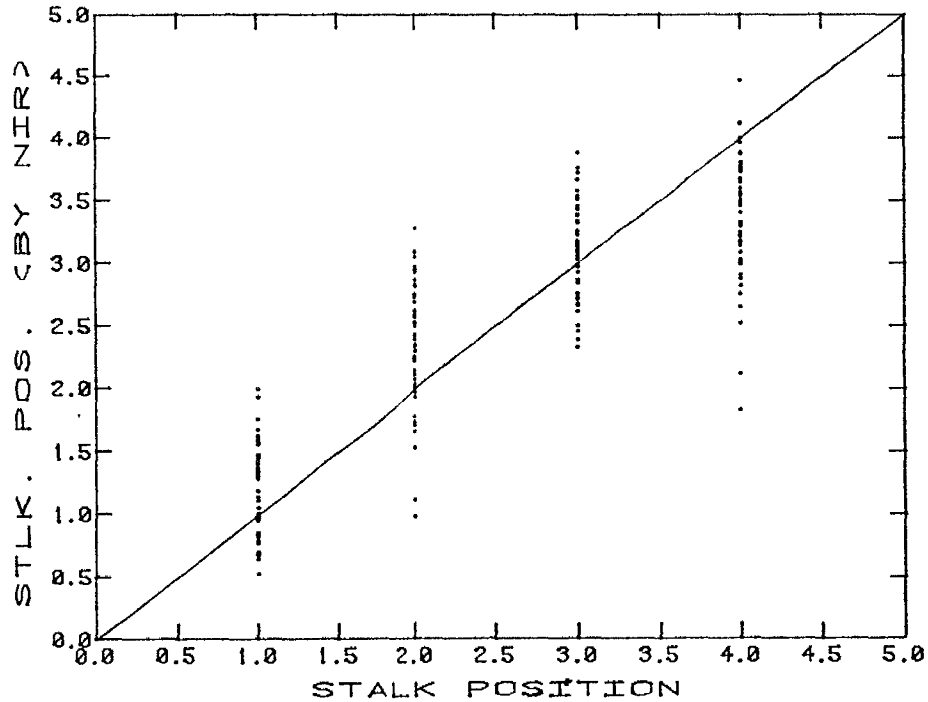

Figure 8. Determining stalk position from 7 wavelengths in a multilinear model.

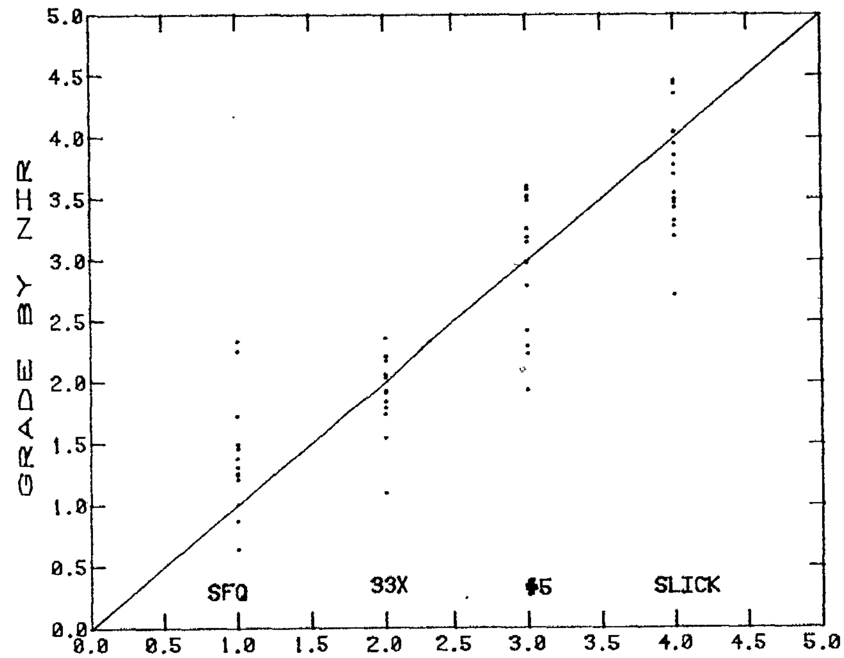

Figure 9. Determining grade by from a 7 wavelength multilinear model.

SEARCH AND MATCH OF TOP TEN

DATE: 7/15/86 TIME: 11:28
REFERENCE FILE: DISTD
UNKNOWN FILE: DIMAR
UNKNOWN SPECTRUM #: 1

KNOWN SPECTRUM	DOT PRODUCT
DIMAR	0.98816
DIBUR	0.96154
DIDRK	0.90580
DIFLU	0.78771

Figure 10. Typical output from the Search and Match Program (SAM).

ACCURACY OF 'SAM' FOR VARIOUS DATA TREATMENTS

TYPE	DATA TREATMENT			
	FO	D1	D2	PW
FLU	100	100	100	99
DRK	100	100	100	100
MAR	83	92	92	38
BUR	84	94	97	84

Figure 11. Performance of the Search and Match Technique.

Title: 03917 - INVESTIGATIONS IN TOBACCO TRANSPLANT PRODUCTION

Project Leader: R. C. Long

Remobilization of Nitrogen During Growth and Senescence of Flue-Cured Tobacco (R. J. Goenaga and R. C. Long)

A ^{15}N experiment was conducted in the field to determine the uptake, accumulation, and distribution of nitrogen in flue-cured tobacco plants (cv. McNair 944) and the remobilization of nitrogen from lower senescing leaves to upper, actively growing ones. Immediately before treatment initiation (crop day 83), soil $^{14}NO_3^-$ was leached from the root zone and was then replaced with an equivalent amount of $^{15}NO_3^-$ (5.7 A% E ^{15}N). Plants were harvested and roots dug from the soil at crop days 83, 90, 96, 106, 113, 127. Plants were separated into 11 different plant parts and analyzed for soluble-reduced N, insoluble N and NO_3^--N, and A% excess ^{15}N.

Upper leaves and roots constituted the major sinks for nitrogen accumulation during the sampling period. Nitrogen was remobilized from lower leaves during periods of limited soil nitrogen uptake. However, roots, rather than the upper leaves, probably were the recipient of this remobilized nitrogen. Because of continued uptake of soil N (both $^{14}NO_3^-$ and $^{15}NO_3^-$) during the sampling period, the remobilization of N from older senescing tissues to other tissues could not be quantified. Movement of N to and from the stalk was observed and may contribute to the nurturing of the young, upper leaves. A model was developed to propose how the remobilization of nitrogen within the plant occurs during periods of limited soil N uptake. During periods of water deficit, significant amounts of insoluble nitrogen were converted to soluble-reduced N components which appear to be converted back into insoluble N components during more favorable environmental conditions.

Physiology of the Growth and Development of Burley Tobacco (P. E. Barney, Jr., R. C. Long, and C. M. Sasscer)

A planting of Ky 14 burley tobacco was grown under standard cultural practices at the Mountain Research Station at Waynesville. Plants were sampled and over-dried on a weekly basis at three leaf positions during the period from grand growth phase to harvest and through curing. Analysis of total alkaloids, sugars, total nitrogen, nitrate nitrogen, and starch are underway.

In 1987, similar samplings will be made, but the green leaves will be iced down and shipped to the laboratory in Raleigh for biochemical analyses. Those analyses will include nitrate reductase, protease, glutamine synthase, ATP sulfurylese, and possibly alpha-amylase and RUBP Case if accurate and reproducible methologies can be developed. Analyses on the dried leaf will also be performed as noted above. Collectively, these analyses should provide a comprehensive picture of the utilization, metabolism, and partitioning of N and C during maturation and senescence of the burley plant.

Using Alar to Restrict Shoot Elongation of Tobacco Transplants (R. C. Long)

Alar has been tested for several years to determine its potential to provide more uniform transplants by restricting shoot elongation and to extend the pulling season. McNair 944 plantbeds were grown in two tests at the Border Belt Tobacco Research Station in a randomized complete block design with four replications. Three treatments were established: a) check, b) early application (EA) (Test 2:Apr 9), or c) late application (LA) (Test 1:Apr 4) (Test 2:Apr 16). Alar at 4000 ppm (a.i.) was sprayed on the beds to the point of run-off.

At various dates, a 1 sq. ft. area from each bed was pulled clean. The stem length of each plant was classified as: a) small, less than 10 cm; b) optimum, 10-17 cm; c) large, greater than 17 cm. Optimum sized plants were transplanted into the field (Test 1:Apr 11; Test 2:Apr 25). The pulling data are presented in Tables 1, 2, and 3.

Table 1. Mean Percentage of Total Plants in the Optimum Category on Each Pulling Date in Test 1

Treatment	Apr 11	Apr 16	Apr 18	Apr 21	Apr 25	Apr 29
Check	37.7	44.6	34.2	31.4	52.6	65.9
LA	21.9	52.2	50.9	55.3	53.9	62.4

Table 2. Mean Percentage of Total Plants in the Large Category on Each Pulling Date in Test 1

Treatment	Apr 11	Apr 16	Apr 18	Apr 21	Apr 25	Apr 29
Check	13.1	40.9	44.2	49.2	24.3	1.1
LA	1.3	2.2	4.1	8.4	11.2	0

Table 3. Mean Percentage of Total Plants in the Small Category on Each Pulling Date in Test 1

Treatment	Apr 11	Apr 16	Apr 18	Apr 21	Apr 25	Apr 29
Check	49.2	15.0	21.6	19.5	23.0	33.0
LA	76.8	45.5	45.0	36.3	34.9	37.6

Alar application resulted in a delay in the transplants reaching the optimum size but thereafter resulted in a higher percentage of optimum sized transplants over the remainder of the pulling period (LA range 50.9 to 62.4%; Check range 31.4 to 65.9%) (Table 1). Comparison of the data in Tables 2 and 3 provide confirmation that Alar application delayed shoot elongation as seen by the smaller number of large plants and the greater number of small plants than the check treatment throughout the pulling period. In addition, the Alar treatment also provided about 10% more total optimum-sized transplants during the pulling period than did the check treatment.

No differences were observed in test 1 for yield or quality index.

The data in Table 4 presents the effects of Alar at a later planting.

Table 4. Mean Percentage of Total Plants in Each size Category at Two Pulling Dates in Test 2

	Small		Optimum		Large	
Treatment	Apr 25	Apr 29	Apr 25	Apr 29	Apr 25	Apr 29
Check	48.2	48.5	42.3	36.8	9.4	14.7
LA	46.0	52.6	46.0	46.0	7.9	1.3
EA	51.1	56.0	48.2	43.3	1.1	0.6

This test also confirms that the earlier the Alar application, the greater is the delay in shoot elongation (i.e., more small plants), the smaller the percentage of large plants, and the larger the percentage of optimum-sized plants. Again, there were no apparent differences in yield or quality index.

Alar was also tested on a few flats in Maynard Wilson's greenhouse near Louisburg. The treated plants developed sturdy stems that were shorter than the plants that Wilson had clipped twice. A few plants were set in the field for comparison with 2X-clipped plants; there were no noticeable differences in the growth of the plants. A bit of epinasty was noticed in the upper leaf or two in the greenhouse on those plants treated with Alar on the first date (4000 ppm). These leaves were probably in the bud at time of treatment, but there was no noticeable effect on other seedling leaves or on leaves on plants in the field. Treatment of a second group of seedlings in the greenhouse did not result in any leaf epinasty. Although this was the first year that any epinasty was observed, future studies will be observed closely to determine if it occurs again and, if so, probable causes of it.

A further study was conducted at the Piedmont Research Station involving Alar, clipping, and combinations of those treatments. McNair 944 seedlings were treated with 4000 ppm Alar on Apr. 30 (Alar only treatment). Plants were clipped (mowed) at 3 1/2" height on May 2 to establish the 1X Clipping, 1X Clipping + Alar, 2X Clipping, and 2X Clipping + Alar treatments. The 2X Clipping and 2X Clipping treatments were clipped a second time on May 7, at a height of about 4 1/2". Alar was applied to the combination treatments on May 7 (1XC+A) and May 15 (2XC+A). Plants were transplanted into the field on May 9 (Check), May 15 (Alar, 1X Clipping, 1XC + Alar), and May 19 (2X Clipping and 2XC+A). Data on the size distribution of the transplants at 5 pulling dates are given in Tables 5, 6, and 7.

Table 5. Mean Percentage of Total Plants in the Optimum Category on Each Pulling Date (Piedmont Research Station)

Treatment	May 9	May 15	May 19	May 22	May 28
Check	63.2	27.3	22.8	27.2	29.7
Alar	10.2	28.9	19.0	26.2	34.6
1X Clipping	2.9	33.9	29.6	27.8	30.6
2X Clipping	0	19.9	29.0	39.3	32.6
1XC+Alar	0	28.0	37.9	39.6	38.1
2XC+Alar	0	13.6	37.0	38.6	36.4

Table 6. Mean Percentage of Total Plants in the Large Category on Each Pulling Date (Piedmont Research Station)

Treatment	May 9	May 15	May 19	May 22	May 28
Check	0.85	50.0	38.0	32.1	48.6
Alar	0	28.8	34.3	12.6	38.5
1X Clipping	0	29.4	41.8	17.8	40.8
2X Clipping	0	0	34.4	15.7	38.4
1XC+A	0	27.2	30.5	19.8	38.1
2XC+A	0	0	30.0	1.7	35.4

Table 7. Mean Percentage of Total Plants in the Small Category on Each Pulling Date (Piedmont Research Station)

Treatment	May 9	May 15	May 19	May 22	May 28
Check	35.9	22.7	39.1	40.7	21.6
Alar	89.8	42.3	46.7	61.2	26.9
1X Clipping	97.1	36.7	28.6	54.4	28.6
2X Clipping	100.0	80.1	36.6	45.0	29.1
1XC+A	100.0	44.8	31.6	40.5	23.8
2XC+A	100.0	86.4	32.9	59.7	28.2

The Alar treatment results were similar to other tests in that such treatment resulted in a greater percentage of smaller plants and a smaller percentage of large plants compared to the check, across the pulling dates. However, other than on the first pulling date, there were no differences among the check and Alar treatments in the percentage of optimum-size plants.

Clipping or the combination of clipping and Alar delayed the elongation of the shoots so that a greater percentage of optimum-size plants was obtained at each of the last 3 pulling dates compared to the check. Imposing an Alar application after clipping (either once or twice) delayed shoot elongation and provided more uniform plants at later pulling dates as did increasing the number of clippings (either with or without Alar).

In this test, the Alar treated plants did not appear to flower earlier than the check plants, in contrast to observations in other years and tests. In fact, there was a general tendency for all treatments, compared to the check, to delay flowering and for a greater number to flower at the same time. For example, approximately 93% of the plants in the Alar, 2X Clipping, and 2X Clipping + Alar treatments flowered between July 25 and August 1, compared to 79% for the check plants.

There was a trend for the yield of the 1X Clipping treatment to be greater than the check. Interestingly, clipping a second time tended to reduce yield over clipping once, whereas, the use of Alar on clipped plants tended to increase yield over the clipping treatments alone. There were no apparent differences in grade index among the treatments.

In summary, the Alar studies in 1986 confirmed earlier observations of

se of the greater number of uniform plants. The
to clipped plants could prove useful by providing more
hose rate of shoot elongation is then restricted, thus
r a longer planting period. Additional combination
made in 1987 to confirm these results.

Producing Transplants by Different Methods (R. C. Long and T. A. Bartholomew)

In the first test, the performance of bare-root transplants from field plantbeds were compared to transplants produced in the greenhouse in either Paperpot honeycomb cells (Type 305; approximately 3 x 3 cm dia.) filled with Tera-Lite Metro-Mix 220 or in Techniculture plugs (4 x 1.9 cm dia.). Pelleted Speight G-28 seed was used for the greenhouse production.

Excellent growth of the seedlings was observed in all three situations. All treatments were transplanted simultaneously and good field growth was observed in all treatments. Delayed growth of the honeycomb cell-grown plants in the field was not observed as in 1985. The plug-grown plants were delayed slightly in flowering but flowered more uniformly than the check (the last 55% of the plants flowered within a 5-day period compared to 40% for the check plants). There were no apparent differences among the treatments for yield or quality.

A second test was performed to determine the feasibility of placing Paperpot honeycomb cells, filled with Metro-Mix 220 and seeded with pelleted Speight G-28 seed, on the bare plantbed, covering them with Reemay, and germinating and growing the seedlings under field conditions. Such a system would eliminate the need for a greenhouse but would provide plants already in a container suitable for either mechanically-assisted or fully automated transplanting.

Germination of the initial seeding was very poor and it was decided that more irrigation, than normally used for field plantbeds, was necessary to completely dissolve the seed coating. When more frequent irrigations were made on a second planting, germination and seedling growth was normal. Transplants were set on May 1 and the performance of plants from the "semi-greenhouse" system were compared to comparable-sized plants from standard plantbeds.

Flowering of the plants produced in this manner was slightly less uniform than the check treatment. However, no differences were noted for yield or quality.

Overall, the concept of producing seedlings in containers such as paper honeycomb cells or plugs under either greenhouse or field conditions has promise. Further consideration of the type of paper, growing media, and irrigation needs is necessary for the development of a system for routine production.

Production of Non-Traditional Types (R. C. Long, D. A. Danehower, and Kimball Brock)

In a continuation of a study begun several years ago, types not normally produced in this country (e.g., Galpao, Amerlinha, "Brazil Special," Samsun) or this area (Burley Ky-14) were grown and air-cured (sun-cured in the case of Samsun) for comparison against Speight G-28 at the Border Belt Tobacco Research Station. Standard flue-cured cultured practices were used except for Samsun in which case no fertilizer application was made and the plants were spaced about 11" in the row.

Leaves were primed from all genotypes (except Samsun) when judged to be ripe by flue-cured standards, strung on sticks, and air-cured in large flue-cured stick barns. Only 1 pilot light was used in each barn to lower the relative humidity to retard leaf molding. Unfortunately, this did not provide sufficient heat to lower the humidity and extensive barn rot of the A priming occurred. Use of 2 pilot lights in subsequent harvests resulted in light color tobaccos, quite unlike the expected color of good air-cured tobacco.

Leaves of the Samsun tobacco were harvested when still green (about 10 days before flue-cured ripeness), strung on sticks, and sun-cured for 5 days. Thereafter, the sticks were placed in the shade for continued curing and drying (about 7 days). The tobacco cured out relatively dark with some aromatic characteristics of commercial Oriental tobacco.

It was concluded that the humidity is probably too high in that area of North Carolina to permit the development of good air-cured color. On the other hand, reasonably good Oriental type tobacco can be produced under those conditions.

Production of Tobacco for Protein and Biomass (R. C. Long and T. A. Bartholomew)

Two studies were conducted at the Border Belt Tobacco Research Station: genotypes and plant population (comparing seeded vs. Techniculture plus or Paperpot honeycomb cell-grown transplants).

Growth and yields were generally consistent with previous studies, with the exception that only three harvests were obtained (June 2/12; July 14, Sept. 10) because of the lack of irrigation water. Consequently, season total yields were reduced by the lack of a fourth harvest.

GRADUATE STUDENTS:

Bartholomew, T. A. (U.S.A.), M.S., under R. C. Long
Goenaga, R. J. (U.S.A.), Ph.D., under R. C. Long and R. J. Volk
Huang, C. H. (Taiwan), M.S., under R. C. Long
Wan Mamat, Zaki (Malaysia), M.S., under R. C. Long
Wu, Z. (P.R.C.), M.S., under R. C. Long

POSTDOCTORAL FELLOW

Barney, P. E., Jr.

MANUSCRIPTS:

Felipe, E. E., and R. C. Long. Management of flue-cured tobacco under excess nitrogen. (Under revision).

Goenaga, R. J., R. J. Volk, and R. C. Long. Uptake and accumulation of nitrogen in flue-cured tobacco. (In preparation).

Goenaga, R. J., R. C. Long, and R. J. Volk. Distribution and remobilization of nitrogen in flue-cured tobacco during field growth and senescence. (In preparation).

THESIS:

Bartholomew, T. A., Jr. 1986. Effect of plant population on biomass and protein production of tobacco grown for protein. M.S. thesis, Crop Science Department.

Goenaga, R. J. 1986. Mobilization of nitrogen in tobacco during field growth and senescence. Ph.D. dissertation, Crop Science Department.

PAPERS PRESENTED AT PROFESSIONAL MEETINGS:

Goenaga, R. J., R. C. Long, and R. J. Volk. Uptake and mobilization of nitrogen in flue-cured tobacco. 32nd Tobacco Workers' Conference, Jan. 12-15, 1987, Baltimore, MD.

Jenkins, R. W., Jr., H. J. Grubbs, R. H. Newman, R. T. Bass, J. S. Brenizer, D. C. Jones, T. G. Williamson, D. A. Danehower, and R. C. Long. Distribution of selected inorganic elements within the leaf in cured bright tobacco. 40th Tobacco Chemists' Research Conference, Oct. 13-16, 1986, Knoxville, TN.

Title: NC05563 - Burley Tobacco Breeding and Genetics

Project Leader: Rebeca C. Rufty

A. Breeding for Virus Resistance (with G. V. Gooding, Jr., and E. A. Wernsman)

Approximately 100 doubled haploid lines derived from the virus resistant, cigar-wrapper cultivar Havana 307, were selected in the greenhouse in previous years for their resistance to tobacco etch (TEV) and tobacco vein mottling (TVMV) viruses. These materials were evaluated in 1986 under field conditions at two research stations. Field disease reactions were highly correlated with greenhouse determinations. Virus resistance has been successfully transferred into the burley phenotype. Back-crossing to the cultivar Ky 14 has been initiated to improve agronomic characteristics of selected burley lines. Field evaluations will continue in 1987.

Breeding lines in the F_3 generation derived from TN-86 and Greenville 131 (possessing an alternative form of TEV and TVMV resistance) were also evaluated. Superior virus resistant material was selected and advanced to the F_4 generation to be further evaluated in 1987. A virus resistant F_1 hybrid (MDH-19 x TN-86) was also developed and found to possess superior agronomic characteristics. This hybrid will be entered in the Official Variety Test program and Regional Small Plot Test program in 1987.

B. Breeding for Black Shank Resistance

Advanced breeding lines and segregating F_2 generations were evaluated for black shank (Phytophthora parasitica var. nicotianae) in a disease nursery located at Rocky Mount, North Carolina. Highly resistant genotypes were identified in 1986 and will be further evaluated in 1987.

C. Breeding for Blue Mold Resistance (with E. A. Wernsman and C. E. Main)

Two blue mold (Peronospora tabacina) resistant breeding lines NC-BMR 42 and NC-BMR 90 are being released by the N. C. Agricultural Research Service. NC-BMR 42 is a flue-cured line derived from the cross Ovens 62 x McNair 944 and resembles McNair 944 in plant type. Disease reactions of NC-BMR 42 did not differ significantly from those of the resistant parent Ovens 62 in 9 environments tested, including Puerto Rico and Mexico. Yield and quality of NC-BMR 42 were not significantly different from those of the blue mold-susceptible commercial cultivar McNair 944 when tested in North Carolina at two locations for two years. NC-BMR 90 is a "half-burley" line derived from the cross Ovens 62 x Ky 17. This line has green color, is highly resistant to blue mold and resembles Ky 17 in plant type. NC-BMR 90 has been back-crossed to Ky 17 to transfer the burley phenotype and improve

agronomic characteristics.

Seventy-five burley lines in the F_3 generation derived from the crosses Ovens 62 x Ky 17 and Ovens 62 x Ky 15 were evaluated for blue mold resistance at Gurabo, Puerto Rico in the winter of 1986. Ten lines were selected as being highly resistant under extremely high disease pressure. It is of importance to note that the Ovens 62 source of blue mold resistance operates even under epidemic conditions and is thus insensitive to high inoculum density.

D. Breeding for Angular Leaf Spot Resistance (with Mary Jo Wannamaker)

A greenhouse screening technique for evaluating tobacco germplasm for resistance to angular leaf spot (*Pseudomonas syringae* pv. *tabaci*) has been developed. Disease reactions resembling field symptoms were obtained when tobacco plants in the 3-4 leaf stage were inoculated with an artist's air brush. Bacterial concentrations used were 10^7 CFU/ml. A mist period of 24 hours following inoculation was required for disease development. A quantitative disease assessment scale was developed using a visual image analyzer which will permit accurate evaluation of germplasm for angular leaf spot reaction.

II. Graduate Students:

Wannamaker, Mary Jo, Ph.D. candidate, Crop Science. Genetic investigations on the angular leaf spot disease of tobacco caused by *Pseudomonas syringae* pv. *tabaci*.

IV. Publications:

Rufty, Rebeca C., Wernsman, E. A., and Gooding, G. V. Jr. 1987. Evaluation of tobacco haploids and doubled-haploids for resistance to tobacco mosaic virus, *Meloidogyne incognita*, and *Pseudomonas syringae* pv. *tabaci* using detached leaves. Phytopathology 77:60-62.

Gooding, G. V., Jr. and Rufty, Rebeca C. 1987. Distribution, incidence and strains of viruses of burley tobacco in North Carolina. Plant Disease 71:38-40

Rufty, Rebeca C. and Reinert, R. A. 1986. Effect of ozone on burley tobacco in presence and absence of tobacco etch or tobacco vein mottling viruses. Phytopathology 76:1096. (Abstract)

V. Manuscripts in Review:

Rufty, Rebeca C., Wernsman, E. A., and Gooding, G. V., Jr. 1987. Inheritance of resistance to tobacco etch virus in Nicotiana tabacum L. cultivar Havana 307. Plant Disease: (In review).

Murphy, J. P., Cox T. S., and Rufty, R. C. 1987. A representation of the pedigree relationships among flue-cured cultivars. Tob. Sci. (In review).

VI. Papers Presented at Professional Meetings

Rufty, R. C., Wernsman, E. A., and Main, C. E. 1987. Evaluation of tobacco germplasm for resistance to tobacco blue mold. The 32nd Tobacco Workers' Conference. January 12-15, 1987. Baltimore, Md.

Rufty, R. C., Miller, R. D., and Gooding, G. V., Jr. 1987. Evaluation of burley tobacco cultivars for resistance to tobacco etch and tobacco vein mottling viruses. The 32nd Tobacco Workers' Conference. January 12-15, 1987, Baltimore, Md.

Rufty, R. C. and Main, C. E. 1986. Evaluation of tobacco germplasm for resistance to tobacco blue mold in Mexico and Puerto Rico. Symposium on tobacco research sponsored by Tabacos Mexicanos. Tepic, Nayarit, Mexico.

IX. Acknowledgements:

I thank the North Carolina Tobacco Foundation, Inc. and R. J. Reynolds Tobacco Company for financial support. Appreciation is expressed to Carroll Sasscer and Dan Wall for their cooperation.

Title: NC 05469 Tobacco Breeding for Germplasm and Varieties Resistant to Pests and Advantageous to Health

Project Leader: G. R. Gwynn

I. Summary of Research:

A. Breeding for Lower Phenol Levels. A continuation of the genetic study concerning total and constituent polyphenols was carried out in 1986. The 1985 crop produced at Reidsville was analyzed by HPLC. In this study, five non-flue-cured tobaccos were each crossed with flue-cured cultivar Speight G-28. Speight G-28 was chosen because it was one of the lowest flue-cured cultivars we have tested. The other parents were chosen because of their low phenol production. 1984 crop results were reported on in the 1985 annual accomplishments. Table 1 shows one of the constituent polyphenols, total chlorogenic acid. Although statistical analyses are incomplete, it would appear that parent 2 is lower than Speight G-28 in each family. In the 1984 crop the F_1 and F_2 means were very close to Speight G-28 but the 1985 crop results shown in Table 1 would not appear to follow this trend. The 1985 crop levels also appeared to be lower in all entries than the 1984 crop (data not shown). Estimates of additive and dominant effect for 1984 and 1985 are shown in Table 2 for three families. Again there are differences between years with little evidence of dominant effects in the 1985 crop as opposed to the presence of dominant effects in the 1984 crop. There is evidence of additive effects for total chlorogenic acid and total polyphenols in both years.

Table 1. Percent total chlorogenic acid (dry weight) - mean values of parents, F_1, and F_2 generations by families - 1985 crop.

TCA	Family				
% D.W.	1 B37	2 L8	3 Va.Bright	4 TI1018	6 TI1281
Speight G-28	1.07a[2/]	.89a	1.01a	1.05a	1.20a
Parent 2[1/]	.06b	.02b	.04b	.05b	.08b
F_1	--	--	.21b	.22b	.13b
F_2	.86a	.40b	.42ab	.15b	.23b

1/ Parent 2 refers to whatever parent is listed in column head.

2/ means with the same letter, within families are not significantly different at the .01 probability level.

Table 2. Additive and dominant effects by families and constituents for 1984 and 1985 crops.

Constituent		Family 3 Va.Bright 1984	Family 3 Va.Bright 1985	Family 4 TI1018 1984	Family 4 TI1018 1985	Family 6 TI1281 1984	Family 6 TI1281 1985
Total chlorogenic acid	a[1/]	.92**[2/]	2.92**	.87**	.50**	.92**	.56**
	d	.58*	-1.10	1.12**	-.37	.27	-.54
Rutin	a	.14*	.08	.21**	.17	.09	.24*
	d	.30**	-.08	.15	-.20	.31**	-.20
Total Polyphenols	a	1.05**	.57*	1.07**	.68*	.95**	.86**
	d	.93**	-.27	1.31**	-.63	.58	-.83

1/ a = additive effect; d = dominant effect.

2/ *,** significantly different from zero at the .05 and .01 level of probability respectively - T test.

A recurrent mass-selection program within a population originating with Speight G-28 and NC 2326 has been carried for six cycles. The base population of the F_2 between Speight G-28 and NC 2326 together with remnant seed of each of the six cycles was grown at Whiteville, Kinston, Oxford and Reidsville in 1986. Each cycle consists of evaluating 45 intercrosses and choosing the lowest 10 entries for total polyphenols (colorimetric method). Intercrosses among selected low entries are made either in the field or greenhouse to produce the next cycle. Remnant seed of intercrosses at each cycle were used in the evaluation. Table 3 shows the mean total phenol level across all locations.

Table 3. Mean total polyphenol level of parents, base population and intercrosses at each cycle for a Speight G-28 (low) by NC 2326 (high) flue-cured cross.

Entry	Mean Percent Total Polyphenol
NC 2326	3.28 a[1/]
F_1	3.04 ab
C_2	2.88 bc
F_2	2.84 bc
C_0	2.80 bc
C_3	2.75 c
C_4	2.73 c
C_5	2.72 c
C_1	2.71 c
Sp G-28	2.70 c

1/ Waller-Duncan K ratio Test.

The application of breeding procedures in a population such as Speight G-28 by NC 2326 would seem to be limited in the amount of progress that could be made in reducing phenol levels. While progress towards the lower parent was achieved the material has not been greatly reduced in phenol level. One advantage, however, is that the material should closely resemble flue-cured tobacco. The other approach of using non-flue-cured germplasm offers much lower levels of phenols but a disadvantage is the introduction of non-flue-cured characteristics.

B. Insect Resistance. Breeding line I514 has been approved by the breeders release board for release as Germplasm NC-I514. NC-I514 is a F_7 line resulting from a cross of Tobacco Introduction (TI) 165 by NC 82. Like TI 165 it has sucrose esters on its leaf surface while NC 82 does not. It is somewhat like flue-cured tobacco but not completely. It more closely resembles its flue-cured tobacco parent in appearance than it does its TI parent. It has budworm resistance expressed as lower infestation in some cases but most commonly as lower survival and rate of growth of budworm larvae. In some tests it seems to have slight hornworm resistance. Yields of sister sub-lines of NC-I514 compare favorably with NC 82 but price per pound and quality index is below NC 82 and about like TI 165. Alkaloid level is equal to or above NC 82. Table 4 shows some of the insect data pertaining to NC-I514.

Table 4. Performance of NC-I514 and checks to budworm infestation.

Entry	Percent Field Infestation	No. Surviving of 5 Larvae	Avg. Larval wt. mgms.
NC I514	4.7	2.75	45
TI 165	1.9	2.13	53
NC 2326	39.0	3.50	270

	Range		
	Percent Field Infestation	Percent Larvae Survival	Avg. Larval wt. mgms.
Sublines of I514	18-43	17-35	43-73
NC 82	78	56	195
TI 165	18	23	40

Table 5. Results from 1986 microplot test of selected breeding lines conducted at Clayton, N. C.

Line	Root Knot Eggs Arenaria	Root Knot Eggs Javanica	Root Knot Eggs Incognita Race 1	Root Knot Larvae Arenaria	Root Knot Larvae Javanica	Root Knot Larvae Incognita Race 2
6685	1000 g [1/]	483 g	11000 g	278 gh	35 h	870 e-h
6690	681 g	3000 g	3000 g	1396 e-g	284 gh	408 gh
6691	552 g	1500 g	8000 g	90 h	82 h	922 e-h
6692	626 g	115 g	2000 g	54 h	40 h	237 gh
6693	1000 g	2000 g	2000 g	108 h	76 h	252 gh
6694	2000 g	6000 g	4000 g	218 gh	528 fg	363 gh
6695	1000 g	2000 g	11000 g	70 h	114 gh	732 e-h
Coker 319	70000 c-e	45000 ef	8900 bc	4790 b	1135 eh	3600 bc
Repanda	0 g	0 g	69000 c-e	0 h	0 h	3290 cd
NC 95	22000 c-g	49000 d-f	9000 g	2018 de	1094 eh	270 gh

[1/] Waller-Duncan K-Ratio = 100.

C. Nematode Resistance. Cooperative work is underway in Florida, Virginia, and North Carolina in an effort to identify and utilize resistance to several species of nematodes. Work in FLorida is emphasizing *javanica* and *arenaria* while work in Virginia is emphasizing cyst resistance.

In 1986 in cooperation with Dr. K. R. Barker, we evaluated several accessions in a micro-plot test at Clayton, N. C. These are lines derived from crosses of *Nicotiana repanda* by *N. longiflora* and in one case from *repanda* by *tabacum*. Table 5 shows some of the results.

D. Breeding for Wilt Resistance. A long term study involving different breeding systems within a common population was concluded in 1986. The base population, an F_2 of a four-way cross involving McNair 944, Coker 319, Speight G-41 and Speight G-15, was tested along with six cycles of several breeding systems. Details of the systems have been given in earlier reports. The evaluation work in 1986 involved replicated tests on disease nurseries at three locations. Results, in Table 6, are reported as disease index. In 1986 the base population was relatively low in disease infestation but in 1983 when a similar test was run, the values for the base population

were higher. Several of the systems were effective in getting back to as low an index as the most resistant parent Sp. G-15. The pedigree system, which was in fact a form of mass selection, and the Mass Selection ID system seemed to be the most effective.

Other material involving a combining of sources of resistance showed promise in developing resistance. A group tested at Oxford in 1986 showed 22 out of 33 lines with resistance as high as NC 95. Another group showed 42 out of 43 lines to be as resistant or more resistant than NC 95.

Table 6. Wilt disease index values for systems, parents, checks, and base population of Cycle 5 - 1986.

System	Disease Index	Parent or Check	Disease Index
Biparental	58	Hicks Ck	91
Pedigree Line 72	55	Va. Gold Ck.	90
Modified Diallel	53	Mc944	79
Mass Sel. PC	53	Coker 319	76
Intercross	51	Sp G-14	59
Paired Cross	51	Sp G-15	58
Pedigree Line 17	44		
Mass Sel. ID	44		
Pedigree Line 54	40		
71037 Base	43		
	LSD 11		

IV. Publications:

Gwynn, G. R. 1986. Registration of NC 60 tobacco. Crop Science 26: p. 1085-1086.

Gwynn, G. R., K. R. Barker, J. J. Reilly, D. A. Komn and S. M. Reed. 1986. Genetic resistance to tobacco mosaic virus, cyst nematodes, root knot nematodes and wildfire from Nicotiana repanda L. Plant Disease 70:958-962.

Arrendale, R. E., R. F. Severson, O. T. Chortyk and G. R. Gwynn. 1986. Alkaloid development in normal and converter tobaccos. Tob. Sci. 30:23-24.

V. Manuscripts Accepted for Publication:

Snook, M. E., W. S. Schlotzhauer, O. T. Chortyk, G. R. Gwynn, and V. A. Sisson. 1987. The development and significance of polyphenols in tobacco leaf and flowers and their relationship to cigarette smoking. 193rd National Meeting, American Chemical Society.

VI. Manuscripts in Review:

None

VII. Papers Presented at Professional Meetings:

Gwynn, G. R. 1987. Comparison of several breeding systems operated for six cycles in developing bacterial wilt resistance - 32nd Tobacco Workers' Conference.

IX. Acknowledgements:

Appreciation is expressed to Mrs. E. H. Brummitt, Mr. B. H. Bunn, Mr. R. M. Critcher and Mrs. J. D. Hardee for valuable technical assistance.

Title: NC 05545 Genetic Investigations of Tobacco and the *Nicotiana* Species

Project Leader: V. A. Sisson

I. Summary of Research:

The objective of this project is to develop new information, technology, and germplasm which will contribute to the development of improved tobacco.

A. Leaf Chemistry of the *Nicotiana* species.

An ongoing study is underway to describe the chemistry of the *Nicotiana* species. This past year emphasis was placed on evaluating the sugar ester fraction. These compounds appear to be important, not only as precursors of smoke flavor constituents, but may also be important factors of insect resistance in some species. In tobacco, sugar esters occur mainly as sucrose esters (Figure 1.). The sucrose esters exist as a series of isomers in which each glucose moiety is completely esterified with a mixture of four molecules of C2-C8 aliphatic acids. Each isomer contains one acetate group at the C6 position and three C3 to C8 acyl moieties at the 2-, 3-, and 4-carbon positions.

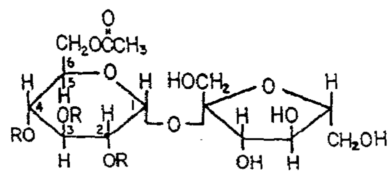

Figure 1. (6-O-acetyl-2,3,4-tri-O-acyl)-α-D-Glycopyranosyl)-β-D-Fructofuranoside

R = Acyl = β-methylvaleryl, isovaleryl, isobutyryl, methylcaproyl, butyryl, valeryl, caproyl, propionyl

Levels of sugar esters ranged from zero up to 292 ug/cm^2. Detectable levels were found in 44 of the 66 species. Species with the highest sugar ester levels (ug/cm^2 leaf area) were *N. meirsii* (292), *N. acuminata* (179), *N. cavicola* (173), *N. trigonophylla* (154), *N. noctiflora* (113), *N. pauciflora* (113), and *N. kawakamii* (112).

Considerable variability in the acid moieties associated with the sucrose ester fraction of each species was noted. Acetic acid was the acid fraction most frequently found as judged by the relative mole distribution of the acid fractions. Other acid moieties found in relatively high proportions were 3-methylvaleric, 2-methylbutyric, 3-methylbutyric, 4-methylhexanoic, heptanoic, 5-methylheptanoic, and 6-methylheptanoic acid. No apparent taxonomic relationships could be associated with the acid distributions of the species. Each species seems to have a somewhat characteristic acid fraction.

B. Development of Disease Resistant Germplasm.

Eighty anther-derived doubled haploids previously screened for resistance to potato virus Y (PVY) were evaluated for yield and quality. PVY resistance was derived from 'Havana 307', a type 54 cigar binder tobacco. None of the resistant doubled haploid lines exceeded the parental flue-cured cultivars, McN 944, NC 82, and Coker 48, in yield although several entries were not statistically different for yield. Several entries were, however, superior to the parental cultivars in quality. The best entries are being rechecked for PVY resistance and will be grown again for yield and quality evaluation.

Efforts continue to transfer root knot (Meloidogyne incognita) resistance from the species Nicotiana tomentosa (acc. 58) into flue-cured tobacco. Resistance is easily recovered in backcross generations, however, fertility and quality remain below normal even after five backcrosses. Testing and selection will continue.

C. Development of Insect Resistant Germplasm.

An anther-derived doubled haploid line selected for resistance to the tobacco budworm but deficient in flue-cured traits was backcrossed in an effort to enhance yield and quality. Four hundred second cycle doubled haploids were screened for budworm resistance under natural field infestations. Resistance was recovered but resistant lines showed little improvement in agronomic characteristics. Efforts to break undesirable linkages between resistance and agronomic characters are underway.

D. Genetic Alteration of Tar/Nicotine Ratio.

Efforts to lower the tar/nicotine ratio in tobacco are being explored. Lowering this ratio has been proposed as one means of reducing the potential hazards of smoking. Lowering the tar/nicotine ratio can be approached in three ways, lowering tar, increasing nicotine, or a combination of these. This investigation focuses mainly on the later two approaches. A high nicotine breeding line, CB-56-7, was crossed with two cultivars, Coker 139 and Md 609, identified as being some of the lowest cultivars in tar delivery. Anther-derived doubled haploid populations were developed. In 1984 over 400 dihaploids were grown in replicated field plots and the cured leaf evaluated for nicotine and tar. One hundred lines were selected and regrown in 1986. Tar values ranged from 19.69 mg/cig to 36.13 mg/cig. Percent nicotine for this same material ranged from 1.83% to 5.27%. The use of near infrared reflectance (NIR) as a means of predicting tar levels is also being investigated. NIR analysis for tar would greatly increase the selection efficiency since sample numbers are greatly limited by the current FTC method for measuring tar.

E. Isozyme Studies.

Attempts are still being made to utilize isozymes as genetic markers in tobacco and the Nicotiana species. Personnel limitations have restricted the

actual progress in this area. Our main efforts so far have been in adapting specific isozyme methodologies to tobacco. At present, we feel proficient with about 10-15 isozyme systems.

II. Graduate Students: none

III. Postdoctoral Fellows: none

IV. Publications:

Jackson, D. M., V. A. Sisson and R. F. Severson. 1986. Tobacco budworm and tobacco hornworm ovipositional preference for *Nicotiana* spp. Annual Plant Resistance to Insects Newsletter. Vol. 12, pp 28-29.

Sisson, V. A. 1986. Current research efforts in tobacco variety development. Tobacco International. May 2. pp. 24-29.

Snook, M. E., P. F. Mason and V. A. Sisson. 1986. Polyphenols in *Nicotiana* species. Tob. Sci. 30:43-49.

V. Manuscripts Accepted for Publication:

None

VI. Manuscripts in Review:

Severson, R. F., J. E. Huesing, D. Jones, R. F. Arrendale and V. A. Sisson. 1986. Characterization of the tobacco hornworm antibiosis factor from the cuticulae of *Nicotiana* Section *Repandae*. Jour. Chem. Ecol.

VII. Papers Presented at Professional Meetings:

Arrendale, R. F., R. F. Severson, V. A. Sisson and M. G. Stephenson. 1986. Characterization of the aliphatic acid amides of nornicotine from the cuticular chemicals of *N. repanda*, *N. stocktonii* and *N. nesophila*. 40th Tobacco Chemists' Research Conference. Knoxville, TN. October 13-16. p. 7. (abstract)

Arrendale, R. F., R. F. Severson, V. A. Sisson and M. G. Stephenson. 1986. Characterization of the sucrose esters of *Nicotiana clevelandii*. SE Regional ACS Meeting, Louisville, KY. November 5-7. (abstract)

Severson, R. F., R. F. Arrendale and V. A. Sisson. 1986. Composition of the sucrose esters from *N. glutinosa*. Georgia Academy of Sciences Annual Meeting. April 28-29.

Severson, R. F., R. F. Arrendale, H. C. Cutler, V. A. Sisson and M. G. Stephenson. 1986. The isolation and quantitation of the major

cuticular components of Nicotiana glutinosa (Acc. 24, 24A, and 24B). SE Regional ACS Meeting. Louisville, KY. November 5-7.

Severson, R. F., H. C. Cutler, V. A. Sisson, D. Jones and M. G. Stephenson. 1986. Cuticular chemistry of Nicotiana repandae. 40th Tobacco Chemists' Research Conference. October 13-16. Knoxville, TN. p. 7.

Severson, R. F., K. L. McDuffie and V. A. Sisson. 1986. Isolation of the major labdane diterpenes and sucrose esters from cuticular extracts of Nicotiana glutinosa (Acc. 24 and 24A). Georgia Academy of Science Annual Meeting. April 28-29.

Sisson, V. A., R. F. Severson, R. F. Arrendale and M. G. Stephenson. 1986. Composition of the acid moieties of the cuticular sugar esters of Nicotiana species. 40th Tobacco Chemists' Research Conference. October 13-16. Knoxville, TN. p. 6.

Snook, M. E., R. F. Arrendale, O. T. Chortyk and V. A. Sisson. 1986. Polyphenols in the leaves and flowers of the Nicotiana species. National American Chemical Society Meeting. Anaheim, CA. September 7-12.

Snook, M. E., W. S. Schlotzhauer, O. T. Chortyk, G. R. Gwynn and V. A. Sisson. 1986. The development and significance of polyphenols in tobacco leaf and flowers and their relationahip to cigarette smoking. SE Regional ACS Meetings. Louisville, KY. November 5-7.

Williamson, R. E., V. A. Sisson and W. F. McClure. 1986. Estimation of total nitrogen in tobacco tissue by near infrared reflectance spectrophotometry. Plant Physiology 80 (4):14.

Jones, D., J. Huesing, J. DeVerna, G. Collins, V. A. Sisson and R. F. Severson. 1987. Novel N-acyl nornicotines from section Repandae impact high antibiosis against a nicotine-resistant insect Manduca sexta. 32nd Tobacco Workers' Conference. January 12-15. Baltimore, MD.

Jackson, D. M., R. F. Severson and V. A. Sisson. 1987. Tobacco budworm oviposition on Nicotiana species. 32nd Tobacco Workers' Conference. January 12-15. Baltimore, MD.

VIII. Graduate Student Theses Completed During Reporting Period: NA

IX. Acknowledgements:

I would like to acknowledge the cooperation of R. F. Arrendale, J. F. Chaplin, G. V. Gooding, D. M. Jackson, R. F. Severson, M. E. Snook and R. E. Williamson. I would also like to acknowledge the excellent technical assistance of E. T. Woodlief, W. H. West, and B. Overton and the statistical and clerical assistance of E. H. Brummitt.

Title: NC05524 - Development and Evaluation of New Sources of *Nicotiana* Germplasm

Project Leader: Sandra M. Reed

I. Summary of Research:

A. Cytogenetic Analysis of *Nicotiana tabacum* Dihaploids

Two studies involving anther culture derived dihaploids of tobacco have been initiated during the past year. The purpose of these studies is to investigate the theory that DNA amplification has occurred in tobacco androgenic dihaploids and that it is this increase in DNA that causes the poor agronomic performance of the dihaploid lines. One way that this theory is being examined is through the use of fluorescence flow cytometry for DNA determinations. Tobacco cultivars 'C139' and 'NC95' and high and low yielding first and second cycle dihaploids derived from these two cultivars are being used as the experimental material. Much of our work so far has involved developing a cell isolation and staining procedure for use with these materials. A reliable procedure that stains for total DNA/nuclei has been developed and is currently being used with the two dihaploid populations. Preliminary experiments with the C139 derived material have shown significant differences between the source cultivar and the dihaploids for amount of DNA, with the low yielding dihaploid lines having the largest amount of DNA. More work is needed, and is currently underway, to verify and expland these findings.

The second study involved a critical cytological analysis of heterochromatin patterns in NC95 and first, second and third cycle dihaploids derived from NC95. Interphase nuclei and pachytene chromosomes were analyzed to determine if changes in heterochromatin amount or distribution as a result of several cycle of anther culture could be discerned. Almost all of the heterochromatin in NC95 is present as chromomeres or small knobs distributed throughout the genome. One "triplet" of three closely aligned knobs and one block, an elongated telomere, were also observed. No changes in these chromosomal markers were observed in any of the dihaploids, nor were any additional large knobs or blocks of heterochromatin observed. Total amount of heterochromatin also appeared to be similar to that observed for NC95.

The conclusion that was made from this study is that if amplification of heterochromatin does occur in *N. tabacum* dihaploids, as has been reported, then the extra heterochromatin must be present as additional small knobs or chromomeres distributed throughout the genome. There was no

evidence of selective amplification of specific heterochromatic segments in any of the dihaploids studied.

B. Rapid Interspecific Gene Transfer

Use of an irradiated pollen procedure for rapid transfer of genes from wild Nicotiana species to N. tabacum has been investigated. Nicotiana tabacum cv. SC58 with a chlorophyll deficient marker, yellow-green (yg), was pollinated with pollen from N. glutinosa that had received 50, 75 or 100 Kr gamma-irradiation. The progeny obtained from these crosses were evaluated for the presence of the green factor from N. glutinosa and for chromosome number. The results of these evaluations are given in Table 1. Progeny were grouped into four categories based on chromosome number. Maternal haploids (24 chromosomes), aneuploid interspecific hybrids (25-35 chromosomes), euploid interspecific hybrids (36 chromosomes) and maternal diploids (48 chromosomes) were obtained from the crosses. With one exception, all green plants were aneuploid or euploid interspecific hybrids. Thus, the dark green coloration of these plants could be explained by the presence of one or more chromosomes from N. glutinosa. The one exception, a dark green 48-chromosome plant, was obtained from a 75 Krad irradiation. Self-progeny obtained from this plant segregated for plant color, thereby indicating that this plant was the product of an accidental pollination with a stray pollen grain from another flue-cured variety. Therefore, the "egg-transformation" phenomenon that has been reported by Pandey to occur in Nicotiana following use of heavily irradiated pollen could not be verified in this study. Other researchers have had similar difficulties when attempting to repeat the original egg-transformation work; therefore, it appears that Pandley's report of this phenomenon may be erroneous.

Although egg-transformation may not occur following use of heavily irradiated Nicotiana pollen, pollen irradiation may be useful in another way for achieving rapid alien gene transfer in Nicotiana. Of the 156 plants obtained from crosses of yellow-green N. tabacum with irradiated N. glutinosa pollen, 55 had partial genomes from N. glutinosa. Eight of these had 27 or less chromosome, and two of these plants carried the dark green factor from N. glutinosa. Thus, use of irradiated pollen may lead to rapid establishment of alien chromosome addition lines that could be used in breeding programs or genetic studies. Application of this procedure for develoment of alien chromosome addition lines will be studied further.

Tabl

Chr.
No.

24
25-3
36
48

TOTA

II.

IV.

V.

VI.

Table 1. Chromosome numbers of green and yellow-green (yg) plants obtained from crosses of yellow-green N. tabacum with irradiated N. glutinosa pollen plants.

Chr.	50Kr		75Kr		100Kr	
No.	green	yg	green	yg	green	yg
24	0	45	0	34	0	7
25-35	37	12	2	4	0	0
36	3	0	0	0	0	0
48	1	0	0	7	0	4
TOTAL	41	57	2	45	0	11

II. Graduate Students:

A. Maria G. Kramer, M.S.

B. Duy N. Huynh, M. S.

IV. Publications:

Reed, S. M. and J. A. Burns. 1986. Cross-restoration between Nicotiana cytoplasmic male sterile and restored lines. J. Hered. 77:159-163.

Reed, S. M. and J. A. Burns. 1986. A modified Nicotiana mitotic chromosome technique. Tob. Sci. 30:83-84.

Gwynn, G. R., K. R. Barker, J. J. Reilly, D. A. Komn, L. G. Burk, and S. M. Reed. 1986. Genetic resistance to tobacco mosaic virus, cyst nematodes, root knot nematodes and wildfire from Nicotiana repanda L. incorporated into Nicotiana tabacum L. Plant Dis. 70:958-962.

V. Manuscripts Accepted for Publication:

Reed, S. M. Cytogenetic Evolution in Nicotiana. In T. Tsuchiya and P. K. Gupta (eds.), Chromosome Engineering in Plants. Genetics, Breeding and Evolution. Elsevier Science Publishers, Amsterdam.

VI. Manuscripts in Review:

Reed, S. M. and J. A. Burns. The nucleolar organizing chromosomes of Nicotiana tabacum L. J. Heredity (in review).

Kramer, M. G. and S. M. Reed. An evaluation of maternal nullihaploidy for the production of nullisomics of Nicotiana tabacum L. I. An interspecific hybridization approach. J. Hered. (in review).

Kramer, M. G. and S. M. Reed. An evaluation of maternal nullihaploidy for the production of nullisomics of Nicotiana tabacum L. II. A pollen irradiation and ovule culture approach. J. Hered. (in review).

VII. Papers Presented at Professional Meetings:

Reed, S. M. and E. A. Wernsman. Use of irradiated pollen in Nicotiana tabacum. 1986. American Society of Agronomy Annual Meetings, New Orleans, LA. Nov. 30-Dec. 5, 1986.

Reed, S. M. Cytological investigatons of anther culture derived dihaploid lines of Nicotiana tabacum. 32nd Tobacco Workers' Conference, Baltimore, MD. Jan. 12-15, 1987.

VIII. Graduate Student Theses Completed During Reporting Period:

Maria G. Kramer. M. S. degree, August 1986. "Production of Nullisomics of Nicotiana tabacum L. via Maternal Haploidy."

Title: Varietal Evaluation Studies in Flue-Cured Tobacco

Project Leader: Daryl Bowman

I. Summary of Research:

A. N. C. Official Variety Test - Tobacco (1986)

Twenty-six released varieties and 30 experimental lines were tested at five locations. NC 95 and NC 2326 were included as standards in these tests.

Up-to-date information is available on the performance of these varieties in the results of the North Carolina Official Variety Research Report No. 107, dated December 1986 from experiments conducted in 1986. The test locations represent growing conditions in the Border, Eastern, Middle and Old Belts in North Carolina. Research Report No. 107 serves as a guide in helping growers choose their 1987 varieties for planting. Copies of this report are mailed to county extension chairmen, seedsmen, and agri-business representatives.

B. Regional Minimum Standards Program

The first phase of the Regional Minimum Standards Program consists of the Regional Small Plot Tests which are located on tobacco experiment stations in the flue-cured region. In North Carolina the tests are located at the Border Belt Tobacco Research Station, Lower Coastal Plain Tobacco Research Station and the Oxford Tobacco Research Station.

In 1986, forty-one entries were included in the Regional Small Plot Test, along with the two standards--NC 2326 and NC 95. A separate publication giving individual location data and combined data for five locations has been distributed to all committee members and other interested parties. Thirteen lines met the minimum standards in the Regional Small Plot Test and may be advanced to the Regional Farm Test in 1987.

The Regional Farm Test is the final phase of the Regional Minimum Standards Program and in 1986 contained ten lines which were evaluated under code by the Variety Evaluation Subcommittee of the Flue-Cured Tobacco Quality Committee. Eight met the minimum standards. The lines were Coker 84-371Y, NC 3415, NC 3003 USDA, NC 3027 USDA, PD 48, Speight G-102, Speight G-108, and VA 110. These have been evaluated for two years in the Regional Small Plot Test and one year in the Regional Farm Test and have met the standards as prescribed. This makes 89 entries that have met the minimum standards since this program was developed. Seed of these eight lines may be available for 1988 plantings should the breeder or agency decide to increase the seed. Data from the Regional Farm

Test are published annually in the Flue-Cured Tobacco Variety Evaluation Committee Report.

II. MS Graduate Student

Terry Kelley

IV. Publications

Bowman, D. T., T. Kelley, and G. Tart. "Measured Crop Performance Tobacco 1986." Research Report No. 107, December 1986.

VI. Manuscripts Released for Publication

Bowman, D. T., T. C. Corbin, and A. G. Tart. Unbiased sampling from tobacco warehouse displays. Tob. Sci. (In Press).

VII. Bowman, D. T., and A. M. Abdelbary. 1987. Associations between certain chemical constituents and physical quality in flue-cured tobacco. 32nd Tob. Workers Conf., Baltimore, MD.

Kelley, W. T., D. T. Bowman, and C. Sasscer, Jr. 1987. Spectral properties of the Burley tobacco leaf during senescence. 32nd Tob. Workers Conf., Baltimore, MD.

ANNUAL REPORT ON TOBACCO WEED CONTROL RESEARCH

March 1, 1986 - February 28, 1987

Title: Project State NCO-3374, "Effective and Efficient Weed Management Programs for Corn, Tobacco, Small Grains and Sorghum."
and
Project State NCO-3569, "Vegetation Control in No-Tillage Crop Production."

Project Leader: A. D. Worsham, Professor, Crop Science Department[1]

Abstract: Imazaquin (Scepter), FMC 57020 (Command) and cinmethylin (Cinch) continued to give acceptable weed control in tobacco when applied immediately after transplanting. There was slight early-season stunting of the crop with Scepter alone at some locations, but yields were not reduced. A combination of Scepter and Command gave the best weed control in conventional and no-till tobacco. Imazethapyr (Pursuit), which is an analog of Scepter, caused more injury to tobacco than Scepter. Clothodim (Select) gave good annual grass control when applied soil-incorporated before transplanting, after transplanting or post emergence to grass. Haloxyfop (Verdict) and quizlofop-ethyl (Assure) gave excellent annual grass control applied postemergence overtop tobacco. Napropamid (Devrinol) mixed with fertilizer gave adequate weed control when the rate of fertilizer applied exceeded 200 lb/A. Incorporated treatments gave better weed control than surface-applied treatments. In a field experiment, activated charcoal mixed in transplant water protected tobacco from a 5X rate of Scepter applied after transplanting. The transplant water treatment was more effective than a root-dip treatment. This approach may also be useful in protecting tobacco from other types of injury from chemicals in the soil. In burley on-farm herbicide tests, diphenamid (Enide) at 6.0 lb ai/A and Devrinol at 2.0 lb ai/A gave good control of hairy galinsoga. Common ragweed control was poor from these as well as Paarlan and Prowl treatments. Yield of no-till flue-cured tobacco was less than conventional except where a 2X rate of base fertilizer was used in a band. Sugar content and grade index of the no-till tobacco was higher than for conventional. The cultivars NF-28 and K-326 had the highest yields in no-till tobacco for the second year. There was vigor and stand reduction of no-till tobacco planted in hairy vetch or crimson clover, although yields were not reduced in the vetch. Quality of the no-till tobacco in the cover crops at Clayton was very high, with grade index values of 64 to 70. At the Mountain Research Station, no-till burley was excellent, with an average yield of 3019 lb/A compared to 2780 lb/A for conventional. Because of severe drought, two on-farm no-till burley tests (planted in killed rye) were failures.

[1]In cooperation with Robert L. Davis, Assoc. Ext. Prof. (Burley tobacco), Mt. Research Station, Waynesville, NC; Tom Wiepke, Grad. Res. Assit.; and technical assistance from Richard Lemons, Res. Technician.

1. Summary of Research (Tests in Group 1)

1. General Experimental Methods: Twelve types of experiments were conducted in the field in 1986. This research will be separated into two major groups. The first group (Group 1) consists of several different tests involving herbicide evaluations in conventional flue-cured tobacco and conventional burley tobacco. The second group (Group 2) consists of several experiments related to the production of no-till flue-cured tobacco and no-till burley tobacco.

The following are the subtitles given to the experiments in Group 1:(A) Herbicide Evaluations in Flue-cured Tobacco -1, (B) Herbicide Evaluations in Flue-cured Tobacco -2, (C) Herbicide Evaluation in Flue-cured tobacco -3, (D) Evaluation of Devrinol Impregnated on Fertilizer for Weed Control in Tobacco, (E) Pre and Postemergence Evaluation of Grass Control Herbicides in Tobacco, (F) Charcoal as a Protectant from Herbicide Injury in Tobacco, and (G) Burley On-Farm Herbicide Tests.

The tests in Group 1 were conducted at the following research stations: Central Crops Research Station near Clayton, the Upper Coastal Plains Research Station near Rocky Mount, Lower Coastal Plains Tobacco Research Station near Kinston, the Upper Piedmont Research Station near Reidsville, and the Mountain Research Station near Waynesville. On-farm tests were conducted in several counties in the burley area of Western North Carolina.

Product description, including chemical names, common names and manufacturers of compounds used in 1986 are given in Table 1. Other detailed information (such as soil description, tobacco varieties, and treatment dates) is included in the narrative with each test. These narrative data tables are in the Appendix, along with weather data and irrigation data. A WSSA approved list of computer codes for weeds reported in this research is given in Table 2 along with other abbreviations used in the report.

Herbicide treatments were applied broadcast with a CO_2 pressurized backpack sprayer having five whirl-chamber nozzles on a boom at 20-inch spacings. The sprayer was operated at 3 mph and 20 psi to deliver 19.1 gal/A. For incorporated treatments, herbicides were disked in immediately after application with a tandem disc harrow set to cut 4 to 6 inches deep and operated at 4 mph. Two-lengthwise trips were made down and back in each plot with the disc. In the surface-applied treatments, all beds were first knocked off to obtain an 8 to 10-inch flat bed top and herbicides were applied broadcast before transplanting. The overtop treatments were applied to the plots immediately after transplanting. Post treatments were applied overtop to the plants three to four weeks after transplanting. After the layby cultivation, herbicides were applied using a two-nozzle boom at 19.1 GPA for a semi-directed spray. Any variations in these methods are given in specific methods for each test.

A. Herbicide Evaluations in Flue-cured Tobacco-1. The herbicides used are listed in Tables 3 and 5. A randomized completed block design with

4 and 3 replications was used at the Kinston and Reidsville locations, respectively. Both tests received two cultivations during the growing season.

Weed control and injury ratings were taken throughout the growing season at both locations. Weed control ratings were based on large crabgrass 1/sq.ft., and prickly sida 1/sq.ft. at the Kinston location.

At Reidsville, weed control ratings were based on large crabgrass 1-3/sq.ft., common ragweed 1-3/sq.ft., prickly sida 1/sq.ft., and green foxtail 1/sq.ft. Injury ratings at both locations were based on percent stunting (0 = no injury and 100 = complete kill).

Results: At Kinston all herbicide treatments gave excellent crabgrass control throughout the growing season (Table 3). In early-season, all herbicide treatments gave excellent prickly sida control except the standard incorporated treatments of Prowl and Paarlan which were fair. Some early-season stunting was noted but by mid-season no visible stunting was observed (Table 3). At the Reidsville location, all overtop treatments were applied nine days after transplanting and some grass had emerged, therefore the standard overtop treatments of Enide and Devrinol didn't give as good grass control as expected (Tables 5 and 6). Some postemergence grass control has been noted with the other overtop treatments in the past and apparently this was the case here with Command and Cinch. All other treatments gave excellent early season large crabgrass control. After cultivations, all herbicide treatments gave excellent grass control through harvest. Command and Scepter gave very good to excellent common ragweed and prickly sida control in early season with all rates and application methods. Cinch, Prowl, Paarlan, Enide and Devrinol were somewhat less effective. Some early-season stunting was observed, but by mid-season no herbicide injury was visibly observed (Tables 5 and 6). There were no important significant differences in yield, grade index or chemical constituents at either location (Tables 4 and 7). Plots treated with Scepter yielded lower than some other treatments at Reidsville (Table 7).

B. Herbicide Evaluations in Flue-cured Tobacco-2. Herbicides used are listed in Table 8. A randomized complete block design with 3 replications was used at the Rocky Mount location. This test received two cultivations during the growing season.

Weed control and injury ratings were made throughout the growing season. Weed control ratings were based on goosegrass 1/sq.ft., carpetweed 1-3/sq.ft., common lambsquarters 1/sq.ft., large crabgrass 1/sq.ft. and redroot pigweed 1/sq.ft. Injury ratings are based on percent stunting (0 = no stunting and 100 = complete kill).

Results: Command at 1.0 lb. a.i./A. applied overtop gave excellent control of grass and broadleaf weeds with the exception of carpetweed which shows tolerance to Command. There was no stunting with Command (Table 8). Scepter at .094 lb. a.i./A applied overtop gave poor early

season goosegrass control but gave very good control of broadleaf weeds. Some slight stunting was observed in early-season. AC 263499 at .094 lb. a.i./A applied overtop gave excellent control of grasses and broadleaf weeds but injured tobacco severely in early-season.

Yields and quality were not included because some harvest data were lost by experiment station personal and herbicide sprayer contamination was suspected in some plots.

C. Herbicide Evaluation in Flue-cured Tobacco-3. The herbicides used are listed in Table 9. A randomized complete block design with 4 replications was used at the Clayton location. This test received two cultivations during the growing season.

Weeds present at Clayton which control ratings were based on were large crabgrass 1/sq.ft., common lambsquarters 1/sq.ft. and redroot pigweed 1-3/sq.ft.

Results: All treatments of Scepter and Command applied overtop gave very good to excellent grass and broadleaf control. Some slight stunting was noted in early-season, but this didn't effect yields (Table 9). Both the overtop and post overtop treatments with Scepter at .094 lb.ai./A wére poor on grass control and fair to good on redroot pigweed control. There were no significant differences in yield, grade index and chemical constituents among herbicie treatments.

D. Evaluation of Devrinol Impregnated on Fertilizer for Weed Control in Tobacco. A randomized complete block design with 4 replications was used at two locations (1 flue-cured and 1 burley). At the Rocky Mount location (flue-cured), Devrinol was impregnated by hand on 15-0-14 fertilizer and the fertilizer applied at the rate of 200#/A broadcast before transplanting. Incorporated treatments were double-disked 2-4 in. deep, then bedded. For surface applied treatments, beds were knocked off and fertilizer broadcast before transplanting. At the Waynesville location (burley), Devrinol was impregnated on 8-8-8 fertilizer and the fertilizer applied at the rate 200#/A broadcast before transplanting for both incorporated and surface treatments. The incorporated treatments were double-disked 2-4 in. deep.

Weed control and injury ratings were taken throughout the growing season. Weed control ratings at Rocky Mount were based on large crabgrass 1/sq.ft., carpetweed 1-3/sq.ft., common lambsquarters 1/sq.ft., goosegrass 1/sq.ft. and redroot pigweed 1/sq.ft. At Waynesville, weeds present were: large crabgrass 1/sq.ft. and hairy galinsoga 1/sq.ft. Injury ratings were on percent stunting (0 = no injury and 100 = complete kill).

Results: At Rocky Mount, impregnated treatments didn't perform as well as the standard treatments for grass or broadleaf control (Table 10). A spotting effect was observed in the impregnated treatments, this may have occurred because of a minimum amount of fertilizer distributed over a large area. Yields were generally good but the low rate of Devrinol alone, surface applied, gave a lower yield than most other

treatments (Table 10). This might have been due to poor pigweed control in late season. The same rate of Devrinol on fertilizer generally gave better control than Devrinol alone. There were no differences in quality among treatments. At Waynesville, all treatments gave excellent control of large crabgrass and hairy galinsoga (Table 11). Because of the large amount of fertilizer used on burley tobacco, distribution was fairly uniform. There was no crop injury observed at either location. At Waynesville, yields of the herbicide treatments did not differ from the controls. The yield for treatment No. 6, Devrinol 2.0 ai/A impregnated on fertilizer was lower than certain other treatments, but the reason is unknown. There was no injury to the plants in this treatment and weed control was good.

E. Pre and Postemergence Herbicide Evaluation of Grass Control Herbicides in Tobacco. Herbicides used are listed in Tables 12 through 14. A randomized complete block design with 4 replications each was used at both Kinston and Rocky Mount locations. Both tests received two cultivations during the growing season. Weed control and injury ratings were taken throughout the growing season. Weed control ratings at Kinston were based on large crabgrass 1/sq.ft. At Rocky Mount weed control ratings were based on large crabgrass 1/sq.ft. and goosegrass 1/sq.ft. Injury ratings were based on percent stunting (0 = no injury and 100 = complete kill) at both locations.

Results: At Kinston, all treatments of Select applied PBI, OT and POT gave excellent grass control throughout the growing season with no differences among rates (Table 12). Both Verdict and Assure applied POT, also gave excellent grass control throughout the season. At the Rocky Mount location, all treatments gave excellent late season control of large crabgrass and goosegrass (Table 13). There was no crop injury observed at either location. There were no significant differences in yield, grade index and chemical constituents among treatments (Tables 12 and 14).

F. Charcoal as a Protectant from Herbicide Injury in Tobacco. Data for this test are given in Table 15. A randomized complete block design with 3 replications was used at the Clayton location. Westvaco powdered charcoal was applied using two methods. With the first method, tobacco transplants were root-dipped in a slurry (1 lb. charcoal/1.5 gal. of water and 100 ml. Ortho X-77 surfactant) immediately before transplanting. In the second method, 1 lb. of charcoal and 100 ml Ortho X-77 surfactant were mixed in 55 gals of transplant water. Because of the extremely dry conditions at transplanting a high water rate was used (400 gal./A) compared to a normal rate (200-250 gal./A). Total charcoal use rate was 7.27 lbs./A. The herbicide imazaquin (Scepter) was chosen for this experiment because of promising results of previous tolerance work on tobacco. Rates used were .125, .250 and .500 lbs. a.i./A. Imazaquin at .125 lbs. a.i. /A is a slightly higher than expected used rate on tobacco with .500 lbs. a.i./A being almost a 5X use rate.

Injury ratings, height measurements and stand counts were taken throughout the growing season. Injury ratings were based on percent stunting (0 = no stunting and 100 = complete kill). Height measurements were average plant height in inches for 10 plants/plot. Stand counts were total plants/plot (two rows X 45 ft.). All plots were cultivated twice during season.

Results: No problems were encountered with either method of charcoal application except that the root-dipped was somewhat more time consuming and messier.

Both methods of charcoal application protected tobacco from imazaquin injury compared to imazaquin treatments without charcoal. However the transplant water method gave significantly higher protection with the 5X rate of imazaquin than the root-dipped method. Surface applied imazaquin injury results were somewhat variable because some herbicide was knocked off the partially flattened row bed in the transplanting operation. Tobacco stand reduction did occur with the 5X rate imazaquin without charcoal and with the root-dipped method. Yield reductions were not as great as expected because the late season rains and late tobacco harvest enabled tobacco to recover remarkably. However, a trend of yield reductions was obtained with the 5X rate without charcoal, 5X rate root-dipped and the no charcoal check. There also appeared to be some stimulation of growth of the tobacco plants from the charcoal alone in the transplant water (Table 15). For example the yield of the cultivated check with charcoal in the transplant water was significantly higher than the cultivated check without charcoal. This approach holds much promise for the future.

G. Burley Tobacco On-Farm Herbicide Tests. Herbicides used are listed in Table 16. Cooperating with R. L. Davis, Burley Extension Specialist, 9 on-farm tests were put out in 8 counties in the burley-producing area in Western North Carolina. Rates used were Prowl (1.0 lb. a.i./A PPI), Devrinol (2.0 lb. a.i./A OT), Enide (4.0 and 6.0 lbs. a.i./A OT), and Paarlan (1.5 lbs. a.i./A PPI). Plot size was 16 feet (4 rows) by 40 feet with 3 replications. Weed control ratings were taken about 21 days after transplanting and before the first cultivation.

Results: The high rate of Enide (6.0 lb. a.i./A OT) and Devrinol (2.0 lb. a.i./A OT) gave very good control of hairy galinsoga (Table 16). All treatments gave poor control of common ragweed. Annual grass control was very good with all treatments. All treatments gave good control of small seeded broadleaf weeds such as common lambsquarters, redroot pigweed, carpetweed and common purslane.

Summary of Research (Tests in Group 2):

1. General Experimental Methods: The second group of experiments were designed to evaluate several aspects of no-till tobacco culture. Included were tests to study fertilization differences in no-till vs. conventional tobacco, weed control and variety evaluation in no-till tobacco and evaluation of cover crops. Land was prepared, soil treatments (soil insecticide/nematicide or multi-purpose fumigant,

depending on location) were applied, and land was bedded in the fall for no-till tobacco. Cover crops were sown and seeds were covered with a rolling cultivator adjusted to fit the beds. Approximately two weeks before transplanting, grain was killed with paraquat and in some cases a half rate of residual herbicide was mixed with the paraquat. Tobacco was transplanted using a modified commercially available no-till one-row transplanter. The transplanter was equipped with a double-disk opener, wide, rubber-tired press wheels and mounted on an articulating frame. A coulter in front of the opener was used where mulch was heavy. Tobacco was fertilized by side-dressing with 40 N - 40 P_2P_5 - 120 (K_2O) at planting and addition of 25 units of N was sidedressed later in the season. Variations in some tests are noted.

All background information is included in the narrative reports for each test (Appendix Tables). Any variations in methods are given in the specific descriptions of each test.

The following are subtitles given to the experiments in Group 2. (H) Fertilization Test (No-till vs. Conventional Tobacco), (I) Herbicide Evaluations in No-till Flue-cured Tobacco, (J) No-till Tobacco Variety Evaluation, (K) Cover Crop Evaluation for No-till Flue-cured Tobacco and (L) Burley Tobacco Herbicide Evaluation (No-till vs. Conventional).

H. Fertilization Test (No-till vs. Conventional Flue-cured Tobacco). Yields, grade index, and chemical constituents are listed in Table 17.

The objective of this experiment was to determine if higher fertilization rates would increase no-till tobacco yields without adversely affecting quality. The two methods of application used were a band knifed into the soil and a broadcast surface application. All broadcast fertilizer treatments were applied two weeks before transplanting. Base fertilization rates after transplanting included standard (40 lb. N), one-half increase in standard (60 lb. N) and 2X increase in standard (80 lb. N). All treatments received 25 lb. N sidedressed two to three weeks after transplanting. A broadcast application of paraquat .5 and diphenamid at 3.0 lbs. a.i./A were applied two weeks before transplanting for grain kill and residual weed control. At transplanting, diphenamid at 3.0 lbs. a.i./A was applied overtop. All band treatments were applied one day after transplanting.

Results: Weed control was very good in early season but by mid-season some mechanical cleanup was needed. Weeds didn't effect tobacco yields (Table 17).

All conventional tobacco treatments out-yielded all no-till tobacco with the high band rate (2X) being the only no-till treatment that was not sign-ificantly different from conventional treatments. Sugar content of the no-till tobacco was higher from the conventional and alkaloid content was lower (Table 17). The average grade index for no-till index was significantly higher than the grade index for conventional tobacco (Table 18).

I. Herbicide Evaluation in No-till Flue-cured Tobacco. Herbicides used are listed in Table 19. The objectives of this test were to evaluate new herbicides and methods of application for improved weed control in a no-till situation. A randomized complete block design with 3 replications was used at the Clayton location.

Weed control and injury ratings were made through mid-season. Weed ratings were based on large crabgrass 1-3/sq.ft., redroot pigweed 1-3/sq.ft. and common lambsquarters 1-3/sq.ft. Injury ratings were based on percent stunting (0 = no stunting and 100 = complete kill). By mid-season weed competition to the tobacco was so severe even in the treatments with fair control, that a decision was made to harvest whole plant green leaf weight.

Results: Rye cover kill was 100% with all treatments. The only treatment that gave acceptable season long grass and broadleaf control was paraquat at .50 lbs. a.i./A applied for rye kill and a tank-mix of Command at .75 lbs. a.i./A plus Scepter at .06 lbs. a.i./A applied overtop after transplanting (Table 19). This combination overcame the weakness of Command on pigweed and Scepter's weakness on crabgrass control. There was slight injury at mid-season from Scepter at 0.125 lb/A. Green weight yields for treatments of paraquat + Command, parquat + Scepter + Command, paraquat + Scepter and paraquat + Devrinol yielded higher than most other treatments.

J. No-Till Tobacco Variety Evaluation. Yield, grade index and leaf chemical constituents results are listed in Table 20. The objectives of this test were to determine if increased yields in no-till tobacco could be obtained by using different varieties and to compare performance among several varieties under no-till conditions. A randomized complete block design was used with 8 replications at the Clayton location. Plot size was one row by 45 ft. with a final stand of 20 plants per plot. Tobacco varieties used were K326, NF 28, C319, NF22, G70, NC82, and C373.

The test was maintained weed free for the entire season by the use of herbicides and hand weeding. Basic fertilizer was knifed into the soil in a band with 40 lbs. of N. A band-surface sidedressing of 25 lb /A of N was applied two to three weeks after transplanting.

Results: There were no significant differences in yield, grade index and chemical constituents among varieties except that NF22 had a higher total alkaloid content than the other varieties. However, both varieties NF-28 and K326 had the highest average yield and maintained their same ranking (1st and 2nd) as in last years results.

K. Efficacy of Legume, Legume and Rye Mixture Cover Crops for No-till Flue-Cured Tobacco. Field experiments were established at Clayton and Rocky Mount research stations in the fall of 1985 to evaluate the feasibility of legume, legume and rye mixture cover crops for no-till flue cured tobacco. The experimental design at both locations was a RCB split-plot with the main plots consisting of the different cover

crop treatments; and the sub-plot treatments were nitrogen at sidedressing and no nitrogen at sidedressing.

Results: Cover crops were well established at both locations by April 15, 1986. Paraquat applications to kill the cover crops began at this time. Rye was in the immature green head stage and both crimson clover and hairy vetch were in the early flowering stage at time of paraquat applications. Three applications of paraquat at 0.5 lb ai/A were required to kill the hairy vetch, hairy vetch and rye mixture cover crops. At both locations after transplanting, all (4 row) main plots received the recommended base N-P-K. Within two weeks of transplanting and re-setting, it was observed that there was a stand reduction in the monoculture crimson clover and hairy vetch main plots at both locations. However, the mixtures did not have a readily observable reduction in stand. Subsequent tobacco stand counts and tobacco height measurements in the monoculture crimson clover and hairy vetch main plots at both locations indicated a 9% reduction in stand and a 13 to 28% reduction in height in the monoculture legume main plots when compared to rye main plots. This overall reduction in tobacco height and vigor in the monoculture legume main plots continued throughout the growing season. Reasons for the apparent incompatibility of legume cover crops and tobacco are not known. The possibility of less moisture in the legume plots at time of transplanting and early in the growing season may be responsible for the poor establishment of the transplants even though irrigation was used. Moisture conditions under the different cover crops will be investigated in the 1987 experiments. Legume mulch and tobacco interactions will be investigated in a greenhouse pot study in the spring of 1987.

Yield and quality of no-till tobacco at Clayton in 1986 was excellent (Table 21). There was a general trend for additional N to improve yields in all cover crops except for hairy vetch. Tobacco in the vetch plots yielded more than any other plots except for the rye + hairy vetch + 30 lb. N treatment. The reduction in stand and plant heights in hairy vetch plots did not adversely affect yield. There was a trend for additional N to lower quality slightly (Table 21).

In the plots with recommended fertility practices at Clayton, yields were highest in hairy vetch and the conventional tilled treatments (Table 22). Yields were low at Rocky Mount and there were no significant differences in yields among treatments. However, crimson clover and hairy vetch plots had the highest average yields.

Quality of the tobacco in this test at Clayton was very high, with index values of 64 to 70, and with no apparent trends (Table 22). Quality of the tobacco in this test at Rocky Mt. was much lower than at Clayton with index values of 36 to 43. There were no apparent trends in this test either, with most no-till plots being equal to the conventional.

L. Burley Tobacco Herbicide Evaluation (No-Till vs. Conventional). Herbicides used are listed in Table 23. A randomized split block

design with 4 replications was used at the Waynesville location. Paraquat at .5 lbs. ai./A was applied three weeks before transplanting, and 100 percent rye kill was obtained. Base fertilizer was broadcast at the rate of 2000 lbs. 8-8-8/A two weeks before transplanting and 150 lbs. of 16-0-0/A was added as a surface sidedressing about three weeks after transplanting.

Weed control ratings were based on percent control of large crab-grass at a density of < 1 sq.ft. Injury ratings were based on percent stunting and some clorotic leaf injury was noted. Conventional tobacco was cultivated twice during growing season.

Results: With light weed pressure, all treatments gave very good season long grass control compared to the two checks (paraquat and cultivated) (Table 23). Some slight early season stunting was observed with Scepter .125 lbs. ai/A applied overtop. However, by harvest no stunting was evident. Chlorotic leaf injury was noted on all plots of conventional tobacco treated with Command 1.0 lb. ai./A applied overtop. No clorotic leaf injury was noted with the same treatment in the no-till tobacco. With the conventional tobacco, growth was more vigorous in the first three weeks after transplanting. This could have affected injury differences. By mid-season all tobacco had grown out the chlorotic leaf injury (Table 23).

There were no significant differences in yields. The average yield for the conventional tobacco was 2780 lb/A and the average yield for the no-till tobacco was 3019 lb/A.

II. Graduate Students:

Tom Wiepke, "No-till tobacco: Effect of Mulch on Herbicide Retention and Evaluation of Cover Crops.

III. Postdoctoral Fellows: None

IV. Publications:

Shilling, D. G., A. D. Worsham and D. A. Danehower. 1986. Influence of mulch, tillage and diphenamid on weed control, yields and quality in no-till flue-cured tobacco. Weed Sci. 34:738-744.

Shilling, D. G., L. A. Jones, A. D. Worsham, C. E. Parker, and R. F. Wilson. 1986. Isolation and identification of some phytotoxic compounds from aqueous extracts of rye (Secale cereale L.). Jour. Agric. Food Chem. 34:633-638.

Walls, F. R., Jr., F. T. Corbin, W. K. Collins, A. D. Worsham, J. R. Bradley and E. M. Lignowski. 1986. Absorption, translocation and metabolism of imazaquin in flue-cured tobacco (Nicotiana tabacum). Proc. South. Weed Sci. Soc. 39:434.

Wood, S. D, and A. D. Worsham. 1986. Reducing soil erosion in tobacco

fields with no-tillage transplanting. Jour. Soil and Water Conserv. 41:193-196.

V. <u>Manuscripts Accepted for Publication:</u>

Walls, F. R. Jr., A. D. Worsham, W. K. Collins, F. T. Corbin and J. R. Bradley. 1987. Evaluation of imazaquin for weed control in flue-cured tobacco. (<u>Nicotiana tabaccum</u>). Weed Sci. 35:(In press).

Worsham, A. D. and R. L. Lemons. 1987. Activated charcoal to reduce injury from potential tobacco herbicides. Proc. South. Weed Sci. Soc. 40:(In press).

Sheets, T. J. and A. D. Worsham. 1987. Effects of soil applied picloram and dicamba on flue-cured tobacco. Proc. South. Weed Sci. Soc. 40:(In press).

VI. Manuscripts in Review:

Walls, F. R. Jr., F. T. Corbin, W. K. Collins, A. D. Worsham, J. R. Bradley and E. M. Lignowski. Absorption, translocation and metabolism of imazaquin in flue-cured tobacco (<u>Nicotiana tabaccum</u>) Weed Sci.

Whatley, L. and A. D. Worsham. Ragweed interference in flue-cured tobacco. Weed Sci.

VII. <u>Papers Presented at Professional Meetings:</u>

Worsham, A. D. and R. L. Lemons. 1987. Activated charcoal to reduce injury from potential tobacco herbicides. Ann. Meet. South. Weed Sci. Soc. January 1987.

Sheets, T. J. and A. D. Worsham. 1987. Effects of soil applied picloram and dicamba on flue-cured tobacco. Ann. Meet. South. Weed Sci. Soc. January 1987.

VIII. <u>Theses Completed During the Reporting Period:</u> None

IX. <u>Acknowledgements:</u>

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Table 1. Herbicides Used in 1986

Company	Common Name or Designation	Trade Name or Other Designation	Formulation	Chemical
American Cyanamid	Imazaquin	Scepter	1.5 lb/gal E	2-(4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl)-3quinolinecarboxylic acid
American Cyanamid	Pendimethalin	Prowl EC	4 lb/gal E	N-1-(ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine
American Cyanamid	Imazethapyr (AC-263499)	Pursuit	1.5 lb/gal S	2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-5-ethyl-3-pyridine-carboxylic acid
American Hoechst	Glufosinate	Ignite	1.67 lb/gal	Ammonium (3-amino-3-carboxypropyl)-methyl-phosphinate
Chevron	Clothodim	Select	2 lb/gal E	{(E,E)-(±)-2-[1-[[(3-chloro-2-propenyl)oxy] imino] propyl]-5-[2-(ethylthio)propyl]-3-hydroxy-2-cyclohexen-1-one]
Chevron		X77	NA	
Chevron	Paraquat	Paraquat CL	2 lb/gal	1,1-dimethyl-4,4-bipyridinium ion
Dow	Haloxyfop	Verdict	2.0 lb/gal	Methyl 2-(4-((3-chloro-5-(trifluoromethyl)-2-pyridinyl)oxy)phenoxy)propanoate
DuPont	Quizalofop-ethyl	Assure	.80 lb/gal E	Ethyl 2-[4-(6-chloro-2-quinoxalynyloxy) phenoxyl] propionate
Elanco	Isopropalin	Paarlan	6.0 lbs/gal EC	2,6-Dinitro-N-N-dipropylcumidine
FMC	FMC57020	Command	4 lb/gal EC	2-(2-Chlorophenyl)methyl-4, 4-dimethtl-3-isoxazol-idinone
Helena		Agridex	NA	Crop Oil Concentrate
Nor Am	Diphenamid	Enide	90W	N,N-dimethyl-2,2-diphenylacetamide
Stauffer	Napropamide	Devrinol	2E	2-(α-napthoxy)-N,N-diethylpropionamide
Shell	Cinmethylin	Cinch	7 lb/gal EC	[exh-1-methyl-4-(methylethyl)-2-[(2-methyl-phenyl)methoxy]-7-oxabicyclo]2.2.1 heptane]

Table 2. WSSA-Approved Computer Code Abbreviations for Weeds* and Other Abbreviations Used in Reporting 1986 Research.

Weeds Reported in 1986 Research

ABBREVIATION*	WEED SPECIES
AMARE	REDROOT PIGWEED
AMBEL	COMMON RAGWEED
CHEAL	COMMON LAMBSQUARTERS
CRINJ	CROP INJURY
DIGIS	SMOOTH CRABGRASS
DIGSA	LARGE CRABGRASS
ELEIN	GOOSEGRASS
GASCI	HAIRY GALINSOGA
G. FOXTL	GREEN FOXTAIL
MOLVE	CARPETWEED
PHBPU	TALL MORNINGGLORY
POLPY	PENN. SMARTWEED
POROL	COMMON PURSLANE
SIDSP	PRICKLY SIDA
Other Abbreviations used for Methods of Application	
PBI	Prebed soil incorporated
PPI	Pretransplant soil incorporated
SUR	Surface applied before transplanting
OT	Over-top tobacco immediately after transplanting

LBY	Semi-directed soil surface treatment after last cultivation
POT	Postemergence over-top tobacco 2 to 3 weeks after transplanting
POD	Applied as a semi-directed postemergence treatment
BAN	Applied over-top tobacco in an 18 inch band immediately after transplanting
GK	Application of herbicide to kill grain about 2 weeks before transplanting
TM	Tank mix of two or more chemicals

*from Composite List of Weeds, Weed Science 32, Suppl. 2.

NORTH CAROLINA STATE UNIVERSITY
HERBICIDE EVALUATION IN FLUE-CURED TOBACCO

TABLE 3

Conducted at KINSTON,N.C. by A.D.WORSHAM AND R.W.LEMONS
Project 86-59-K with cooperator LOWER COASTAL PLAIN TOBACCO RESEARCH STATION

TRT. NUM.	PEST. NAME	FORM	RATE #ai/A	GROW. STAGE	DIGSA 5-28	SIDSP 5-28	CRINJ 5-28	CRINJ 7-15	DIGSA 8-27	CRINJ 8-27
01	COMMAND	6.00E	0.75	PBI	98.0	98.8	3.8	0.0	99.0	0.0
02	COMMAND	6.00E	1.00	PBI	99.0	97.0	5.0	0.0	99.0	0.0
03	COMMAND	6.00E	1.25	PBI	99.0	99.0	1.3	0.0	95.5	0.0
04	COMMAND	6.00E	0.75	OT	99.0	99.0	1.3	0.0	97.8	0.0
05	COMMAND	6.00E	1.00	OT	99.0	99.0	5.0	0.0	98.0	0.0
06	COMMAND	6.00E	1.25	OT	99.0	96.8	1.3	0.0	98.0	0.0
07	CINCH	7.00E	0.75	OT	98.8	89.8	3.8	0.0	98.0	0.0
08	CINCH	7.00E	1.00	OT	98.8	89.8	5.0	0.0	99.0	0.0
09	SCEPTER	1.50E	.060	OT	96.8	98.8	10.0	0.0	99.0	0.0
10	SCEPTER	1.50E	.094	OT	93.3	96.3	6.3	0.0	95.3	0.0
11	COMMAND	6.00E	0.75	OTTM	98.8	98.8	6.3	0.0	95.3	0.0
11	SCEPTER	1.50E	.060	OTTM						
12	PROWL	4.00E	1.00	PBI	88.5	66.0	7.5	0.0	93.0	0.0
13	PAARLAN	6.00E	1.50	PBI	98.8	73.8	5.0	0.0	98.8	0.0
14	ENIDE	0.90W	6.00	OT	98.8	96.8	0.0	0.0	98.0	0.0
15	DEVRINOL	2.00E	1.00	OT	97.0	91.0	5.0	0.0	98.0	0.0
16	COMMAND	6.00E	0.75	BAN	93.3	85.8	10.0	0.0	98.0	0.0
17	COMMAND	6.00E	1.00	BAN	94.5	94.5	1.3	0.0	98.8	0.0
18	COMMAND	6.00E	1.25	BAN	94.3	94.5	6.3	0.0	98.8	0.0
19	CULT CK		0000		33.8	24.5	0.0	0.0	73.8	0.0
LEAST SIGNIFICANT DIFF. (.05)=					14.39	25.01	6.726	0	6.250	0
STANDARD DEVIATION =					10.18	17.68	4.756	0	4.420	0
COEFF. OF VARIABILITY =					10.87	19.89	107.9	0	4.587	0

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NORTH CAROLINA STATE UNIVERSITY
HERBICIDE EVALUATION IN FLUE-CURED TOBACCO

TABLE 4

Conducted at KINSTON,N.C. by A.D.WORSHAM AND R.W.LEMONS
Project 86-59-K with cooperator LOWER COASTAL PLAIN TOBACCO RESEARCH

TRT. NUM.	PEST. NAME	FORM	RATE #ai/A	GROW. STAGE	YIELD LBS/A	GRADE INDEX	% SUGAR	% TA(HY)
01	COMMAND	6.00E	0.75	PBI	2926.8	37.10	8.2000	3.115
02	COMMAND	6.00E	1.00	PBI	2678.5	41.43	9.4750	3.010
03	COMMAND	6.00E	1.25	PBI	2712.5	36.72	10.5750	2.863
04	COMMAND	6.00E	0.75	OT	2816.3	39.72	9.6000	2.953
05	COMMAND	6.00E	1.00	OT	2747.3	43.00	9.0250	3.113
06	COMMAND	6.00E	1.25	OT	2797.5	42.48	9.4250	3.120
07	CINCH	7.00E	0.75	OT	2686.8	44.65	9.3750	2.918
08	CINCH	7.00E	1.00	OT	2890.5	43.25	9.3500	2.875
09	SCEPTER	1.50E	.060	OT	2641.8	40.07	8.7250	2.933
10	SCEPTER	1.50E	.094	OT	2682.5	42.30	9.2250	2.893
11	COMMAND	6.00E	0.75	OTTM	2559.0	44.35	10.8500	2.948
11	SCEPTER	1.50E	.060	OTTM				
12	PROWL	4.00E	1.00	PBI	2889.3	39.05	7.8000	2.943
13	PAARLAN	6.00E	1.50	PBI	2754.3	43.98	8.9750	3.108
14	ENIDE	0.90W	6.00	OT	2702.8	42.85	9.9250	2.973
15	DEVRINOL	2.00E	1.00	OT	2816.5	40.02	8.9500	3.028
16	COMMAND	6.00E	0.75	BAN	2657.0	47.38	10.1250	2.940
17	COMMAND	6.00E	1.00	BAN	2724.0	43.65	9.2500	3.125
18	COMMAND	6.00E	1.25	BAN	2576.5	48.38	10.6750	2.663
19	CULT CK		0000		2779.3	40.50	9.3500	2.907
LEAST SIGNIFICANT DIFF. (.05)=					261.1	6.630	2.653	.2840
STANDARD DEVIATION =					184.6	4.688	1.876	.2008
COEFF. OF VARIABILITY =					6.743	11.12	19.93	6.762

2000269976

NORTH CAROLINA STATE UNIVERSITY
HERBICIDE EVALUATION IN FLUE-CURED TOBACCO

TABLE 5

Conducted at REIDSVILLE,N.C. by A.D.WORSHAM AND R.W.LEMONS
Project 86-60-RD with cooperator UPPER PIEDMONT RESEARCH STATION

TRT. NUM.	PEST. NAME	FORM	RATE #ai/A	GROW. STAGE	DIGSA 6-19	AMBEL 6-19	SIDSP 6-19	CRINJ 6-19	DIGSA 7-17	G.FOXTL 7-17	AMBEL 7-17	CRINJ 7-17
01	COMMAND	6.00E	0.75	PBI	99.0	94.3	99.0	3.3	99.0	99.0	94.3	0.0
02	COMMAND	6.00E	1.00	PBI	98.7	98.7	98.7	6.7	99.0	99.0	99.0	0.0
03	COMMAND	6.00E	1.25	PBI	99.0	99.0	99.0	6.7	99.0	99.0	99.0	0.0
04	COMMAND	6.00E	0.75	DT	97.3	88.0	94.3	5.0	99.0	99.0	94.7	0.0
05	COMMAND	6.00E	1.00	DT	98.7	99.0	99.0	3.3	99.0	99.0	99.0	0.0
06	COMMAND	6.00E	1.25	DT	99.0	88.0	92.7	3.3	99.0	99.0	94.3	0.0
07	CINCH	7.00E	0.75	DT	97.7	69.7	73.0	5.0	99.0	99.0	71.7	0.0
08	CINCH	7.00E	1.00	DT	97.7	70.0	83.0	3.3	97.3	97.3	65.0	0.0
09	SCEPTER	1.50E	.060	DT	94.3	84.3	87.7	10.0	93.7	94.7	84.7	0.0
10	SCEPTER	1.50E	.094	DT	90.0	97.7	97.7	11.7	93.0	93.0	93.0	0.0
11	COMMAND	6.00E	0.75	DTTM	99.0	99.0	99.0	3.3	99.0	99.0	97.7	0.0
11	SCEPTER	1.50E	.060	DTTM								
12	PROWL	4.00E	1.00	PBI	98.7	50.0	98.3	11.7	97.7	99.0	73.3	0.0
13	PAARLAN	6.00E	1.50	PBI	89.3	40.0	59.3	5.0	99.0	99.0	55.0	0.0
14	ENIDE	0.90W	6.00	DT	69.3	55.0	70.0	3.3	99.0	93.0	53.3	0.0
15	DEVRINOL	2.00E	1.00	DT	56.3	56.3	56.3	0.0	99.0	93.0	61.7	0.0
16	COMMAND	6.00E	0.75	BAN	97.3	76.7	84.7	5.0	99.0	99.0	88.3	0.0
17	COMMAND	6.00E	1.00	BAN	96.0	84.7	99.0	1.7	99.0	99.0	99.0	0.0
18	COMMAND	6.00E	1.25	BAN	97.7	97.7	99.0	10.0	99.0	99.0	99.0	0.0
19	CULT CK		0000		16.7	16.7	16.7	1.7	46.7	53.3	36.7	0.0
LEAST SIGNIFICANT DIFF. (.05)=					23.61	28.74	32.07	7.371	9.501	6.481	17.58	0
STANDARD DEVIATION =					14.31	17.41	19.43	4.467	5.758	3.927	10.65	0
COEFF. OF VARIABILITY =					16.07	22.59	22.99	84.87	6.030	4.119	12.99	0

NORTH CAROLINA STATE UNIVERSITY
HERBICIDE EVALUATION IN FLUE-CURED TOBACCO

TABLE 6

Conducted at REIDSVILLE,N.C. by A.D.WORSHAM AND R.W.LEMONS
Project 86-60-RD with cooperator UPPER PIEDMONT RESEARCH STATION

TRT. NUM.	PEST. NAME	FORM	RATE #ai/A	GROW. STAGE	DIGSA 9-11	G.FOXTL 9-11	AMBEL 9-11	CRINJ 9-11
01	COMMAND	6.00E	0.75	PBI	98.7	99.0	89.3	0.0
02	COMMAND	6.00E	1.00	PBI	99.0	99.0	99.0	0.0
03	COMMAND	6.00E	1.25	PBI	99.0	99.0	99.0	0.0
04	COMMAND	6.00E	0.75	OT	98.7	99.0	88.3	1.7
05	COMMAND	6.00E	1.00	OT	98.7	99.0	99.0	1.7
06	COMMAND	6.00E	1.25	OT	99.0	99.0	89.3	0.0
07	CINCH	7.00E	0.75	OT	99.0	99.0	53.3	1.7
08	CINCH	7.00E	1.00	OT	96.3	96.3	51.7	0.0
09	SCEPTER	1.50E	.060	OT	86.7	93.0	66.3	3.3
10	SCEPTER	1.50E	.094	OT	88.0	88.0	83.0	0.0
11	COMMAND	6.00E	0.75	OTTM	99.0	99.0	97.7	0.0
11	SCEPTER	1.50E	.060	OTTM				
12	PROWL	4.00E	1.00	PBI	96.0	97.7	58.3	5.0
13	PAARLAN	6.00E	1.50	PBI	97.7	99.0	40.0	0.0
14	ENIDE	0.90W	6.00	OT	97.7	86.0	35.0	5.0
15	DEVRINOL	2.00E	1.00	OT	99.0	96.0	40.0	0.0
16	COMMAND	6.00E	0.75	BAN	99.0	99.0	81.7	0.0
17	COMMAND	6.00E	1.00	BAN	99.0	97.7	98.0	3.3
18	COMMAND	6.00E	1.25	BAN	99.0	99.0	99.0	0.0
19	CULT CK		0000		16.7	16.7	16.7	0.0
LEAST SIGNIFICANT DIFF. (.05)=					12.50	13.39	28.48	3.768
STANDARD DEVIATION =					7.579	8.118	17.26	2.283
COEFF. OF VARIABILITY =					8.154	8.762	23.69	200.2

NORTH CAROLINA STATE UNIVERSITY
HERBICIDE EVALUATION IN FLUE-CURED TOBACCO

TABLE 7
Conducted at REIDSVILLE,N.C. by A.D.WORSHAM AND R.W.LEMONS
Project 86-60-RD with cooperator UPPER PIEDMONT RESEARCH STATION

TRT. NUM.	PEST. NAME	FORM	RATE #ai/A	GROW. STAGE	YIELD LBS/A	GRADE INDEX	% SUGAR	% TA(HY)
01	COMMAND	6.00E	0.75	PBI	2506.7	50.60	17.0	2.00
02	COMMAND	6.00E	1.00	PBI	2467.7	52.63	14.7	2.17
03	COMMAND	6.00E	1.25	PBI	2670.0	45.97	15.7	2.33
04	COMMAND	6.00E	0.75	OT	2323.3	46.73	14.7	2.50
05	COMMAND	6.00E	1.00	OT	2305.0	55.97	19.3	1.97
06	COMMAND	6.00E	1.25	OT	2369.0	49.87	16.0	2.20
07	CINCH	7.00E	0.75	OT	2382.0	54.77	15.0	2.00
08	CINCH	7.00E	1.00	OT	2361.7	49.00	16.7	2.03
09	SCEPTER	1.50E	.060	OT	2025.3	49.33	12.3	2.23
10	SCEPTER	1.50E	.094	OT	2331.3	42.60	12.0	2.17
11	COMMAND	6.00E	0.75	OTTM	2601.3	53.87	14.3	2.27
11	SCEPTER	1.50E	.060	OTTM				
12	PROWL	4.00E	1.00	PBI	2329.3	56.37	13.7	2.23
13	PAARLAN	6.00E	1.50	PBI	3092.0	51.77	14.3	2.47
14	ENIDE	0.90W	6.00	OT	2471.7	52.13	15.7	2.37
15	DEVRINOL	2.00E	1.00	OT	2538.7	45.00	13.3	2.47
16	COMMAND	6.00E	0.75	BAN	2435.7	49.20	11.7	2.40
17	COMMAND	6.00E	1.00	BAN	2653.3	46.23	13.3	2.50
18	COMMAND	6.00E	1.25	BAN	2711.0	46.00	15.0	2.30
19	CULT CK		0000		2324.0	53.20	15.0	2.37
LEAST SIGNIFICANT DIFF. (.05)=					731.6	10.30	7.192	.6473
STANDARD DEVIATION =					443.3	6.242	4.358	.3923
COEFF. OF VARIABILITY =					17.96	12.46	29.61	17.34

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HERBICIDE EVALUATION IN FLUE-CURED TOBACCO

TABLE 8

Conducted at ROCKY MOUNT,N.C. by A.D.WORSHAM AND R.W.LEMONS
Project 86-64-RM with cooperator UPPER COASTAL PLAIN RESEARCH STATION

TRT. NUM.	PEST. NAME	FORM	RATE #ai/A	GROW. STAGE	ELEIN 6-11	MOLVE 6-11	CHEAL 6-11	CRINJ 6-11	DIGSA 7-14	ELEIN 7-14	AMARE 7-14	CRINJ 7-14	DIGSA 9-10	ELEIN 9-10	AMARE 9-10
01	SCEPTER	1.50E	.094	OT	58.3	89.7	96.0	11.7	90.0	81.7	99.0	0.0	86.7	70.0	99.0
02	SCEPTER	1.50E	.094	POT	0.0	0.0	0.0	11.7	56.7	53.3	81.7	0.0	40.0	33.3	74.7
03	SCEPTER	1.50E	.094	LBY	0.0	0.0	0.0	6.7	56.7	53.3	87.7	0.0	46.7	46.7	76.7
04	AC263499	1.50E	.094	DT	97.7	99.0	99.0	66.7	78.3	72.7	99.0	33.3	70.0	70.0	99.0
05	AC263499	1.50E	.094	POT	0.0	0.0	0.0	0.0	53.3	56.7	68.0	0.0	50.0	53.3	78.0
06	COMMAND	6.00E	1.00	OT	99.0	0.0	99.0	0.0	98.7	99.0	99.0	0.0	97.3	96.0	98.7
07	COMMAND	6.00E	1.00	LBY	16.7	0.0	0.0	0.0	89.3	91.0	90.0	0.0	78.3	75.0	79.3
08	COMMAND	6.00E	0.75	OTTM	99.0	97.7	99.0	8.3	97.7	98.7	98.7	0.0	97.3	97.3	95.7
08	SCEPTER	1.50E	0.06	OTTM											
09	CULT CK		0000		0.0	0.0	0.0	5.0	20.0	16.7	36.7	0.0	0.0	0.0	32.7
LEAST SIGNIFICANT DIFF. (.05)=					19.12	7.374	2.998	12.06	18.66	19.75	23.02	16.65	12.64	15.60	37.77
STANDARD DEVIATION =					11.05	4.260	1.732	6.972	10.78	11.41	13.30	9.622	7.307	9.129	21.82
COEFF. OF VARIABILITY =					26.83	13.39	3.966	57.04	15.16	16.48	15.35	259.8	11.61	15.16	26.66

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TABLE 9 H

TRT. NUM.	PEST. NAME	FORM	RAT #ai
01	SCEPTER	1.50E	.09
02	SCEPTER	1.50E	.09
03	SCEPTER	1.50E	.09
04	COMMAND	6.00E	1.0
05	COMMAND	6.00E	0.7
05	SCEPTER	1.50E	0.0
06	CULT CK		000

LEAST SIGNIFICANT DIF
STANDARD DEVIATION
COEFF. OF VARIABILITY

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TABLE 9 **HERBICIDE EVALUATION IN FLUE-CURED TOBACCO - 3**

Conducted at CLAYTON,N.C. by A.D.WORSHAM AND R.W.LEMONS
Project 86-79-C with cooperator CENTRAL CROPS RESEARCH STATION

TRT. NUM.	PEST. NAME	FORM	RATE #ai/A	GROW. STAGE	DIGSA 5-19	CHEAL 5-19	AMARE 5-19	CRINJ 5-19	DIGSA 9-2	AMARE 9-2	YIELD LBS/A	GRADE INDEX	% SUGAR	% TA(HY)
01	SCEPTER	1.50E	.094	DT	98.8	99.0	99.0	8.8	80.0	99.0	3169.8	58.43	11.38	2.985
02	SCEPTER	1.50E	.094	POT	12.5	12.5	12.5	0.0	68.8	74.8	3093.8	62.20	12.70	2.783
03	SCEPTER	1.50E	.094	LBY	12.5	12.5	12.5	5.0	65.0	83.3	3102.3	65.20	11.53	3.045
04	COMMAND	6.00E	1.00	OT	99.0	99.0	96.8	6.3	93.0	83.5	2996.8	63.18	11.63	2.930
05	COMMAND	6.00E	0.75	OTTM	99.0	99.0	99.0	10.0	89.8	99.0	3169.5	63.75	11.25	2.923
05	SCEPTER	1.50E	0.06	OTTM										
06	CULT CK		0000		20.0	20.0	20.0	1.3	32.5	31.3	3029.3	64.93	11.20	2.830
LEAST SIGNIFICANT DIFF. (.05)=					21.84	21.89	21.60	8.357	29.21	39.27	278.7	6.015	1.808	.2475
STANDARD DEVIATION =					14.49	14.52	14.33	5.546	19.38	26.06	185.0	3.992	1.200	.1642
COEFF. OF VARIABILITY =					25.45	25.49	25.31	106.4	27.11	33.22	5.980	6.342	10.33	5.633

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EVALUATION OF DEVRINOL IMPREGNATED ON FERTILIZER IN TOBACCO

TABLE 10

Conducted at ROCKY MOUNT,N.C. by A.D.WORSHAM AND R.W.LEMONS
Project 86-51-RM with cooperator UPPER COASTAL PLAIN RESEARCH STATION

TRT. NUM.	PEST. NAME	FORM	RATE #ai/A	GROW. STAGE	DIGSA 6-11	MOLVE 6-11	CHEAL 6-11	CRINJ 6-11	DIGSA 9-10	ELEIN 9-10	AMARE 9-10	YIELD LB/A	QUALITY G.INDEX
01	DEVRINOL	2.00E	1.00	PBI	97.8	98.8	97.8	0.0	97.8	96.8	98.0	2638.5	37.3[illegible]
02	DEVRINOL	2.00E	2.00	PBI	98.8	99.0	99.0	2.5	99.0	99.0	99.0	3102.0	35.68
03	DEVRINOL ON-FERT	2.00E	1.00	PBI	95.8	89.8	96.0	0.0	87.0	88.0	89.5	2815.3	37.43
04	DEVRINOL ON-FERT	2.00E	2.00	PBI	78.8	49.8	86.8	0.0	69.5	50.0	73.8	2669.3	40.38
05	DEVRINOL ON-FERT	2.00E	1.00	SUR	92.3	61.3	83.8	0.0	87.3	82.0	69.5	2793.8	40.88
06	DEVRINOL ON-FERT	2.00E	2.00	SUR	94.3	73.8	79.8	0.0	94.0	87.3	99.0	2767.0	40.63
07	DEVRINOL	2.00E	1.00	SUR	92.3	62.5	74.8	0.0	67.5	50.0	64.8	2008.3	41.47
08	DEVRINOL	2.00E	2.00	SUR	75.0	48.8	74.8	0.0	65.0	57.5	90.3	2751.5	39.53
09	CULT CK		0000	PBI	0.0	0.0	0.0	0.0	37.5	43.8	45.0	2275.8	42.28
10	CULT CK		0000	SUR	0.0	0.0	21.3	0.0	10.0	10.0	15.0	2441.5	41.45
LEAST SIGNIFICANT DIFF. (.05)=					14.59	23.65	27.74	2.294	25.01	23.55	24.82	398.3	7.967
STANDARD DEVIATION =					10.06	16.30	19.12	1.581	17.23	16.23	17.10	274.5	5.490
COEFF. OF VARIABILITY =					13.88	27.94	26.79	632.4	24.12	24.43	23.00	10.43	13.82

NORTH CAROLINA STATE UNIVERSITY
EVALUATION OF DEVRINOL IMPREGNATED ON FERTILIZER IN TOBACCO

Table 11 Conducted at WAYNESVILLE,N.C. by A.D.WORSHAM AND R.W.LEMONS
Project 86-52-W with cooperator MOUNTIAN RESEARCH STATION

TRT. NUM.	PEST. NAME	FORM	RATE #ai/A	GROW. STAGE	DIGSA 6-24	CRINJ 6-24	DIGSA 9-16	H.GALIN 9-16	CRINJ 9-16	YIELD LBS./A
01	DEVRINOL	2.00E	1.00	PBI	99.0	0.0	99.0	96.8	0.0	2944.3
02	DEVRINOL	2.00E	2.00	PBI	99.0	0.0	99.0	99.0	0.0	2924.0
03	DEVRINOL 03 ON-FERT	2.00E	1.00	PBI	99.0	0.0	99.0	95.5	0.0	3412.3
04	DEVRINOL 04 ON-FERT	2.00E	2.00	PBI	99.0	0.0	99.0	98.0	0.0	3103.5
05	DEVRINOL 05 ON-FERT	2.00E	1.00	SUR	99.0	0.0	99.0	96.8	0.0	3194.8
06	DEVRINOL 06 ON-FERT	2.00E	2.00	SUR	99.0	0.0	99.0	99.0	0.0	2401.8
07	DEVRINOL	2.00E	1.00	SUR	99.0	0.0	99.0	96.8	0.0	3372.0
08	DEVRINOL	2.00E	2.00	SUR	99.0	0.0	99.0	99.0	0.0	3373.8
09	CULT CK		0000	PBI	33.8	0.0	47.5	35.0	0.0	3076.5
10	CULT CK		0000	SUR	30.0	0.0	37.5	27.5	0.0	2911.0
LEAST SIGNIFICANT DIFF. (.05) =					22.74	0	13.67	15.38	0	754.5
STANDARD DEVIATION =					15.67	0	9.428	10.60	0	520.0
COEFF. OF VARIABILITY =					18.31	0	10.75	12.57	0	16.93

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PRE-POSTEMERGENCE HERBICIDE SCREENING FOR GRASS CONTROL IN TOBACCO

Table 12

Conducted at KINSTON,N.C. by A.D.WORSHAM AND R.W.LEMONS
Project 86-61-K with cooperator LOWER COASTAL PLAIN TOBACCO RESEARCH STATION

TRT. NUM.	PEST. NAME	FORM	RATE #ai/A	GROW. STAGE	DIGSA 5-28	CRINJ 5-28	DIGSA 6-19	CRINJ 6-19	CRINJ 7-16	DIGSA 8-13	CRINJ 8-13	YIELD LB/A	GRADE INDEX	% SUGAR	% TA(HY)
01	SELECT	2.00E	.125	PPI	97.8	0.0	98.8	0.0	0.0	99.0	0.0	2512.3	58.32	10.8500	2.800
02	SELECT	2.00E	0.25	PPI	95.5	0.0	99.0	0.0	0.0	99.0	0.0	2310.3	57.98	9.7750	2.950
03	SELECT	2.00E	.125	OT	98.8	0.0	98.8	0.0	0.0	98.8	0.0	2355.3	56.83	9.7500	2.723
04	SELECT	2.00E	0.25	OT	99.0	0.0	99.0	0.0	0.0	99.0	0.0	2609.3	58.88	12.0000	2.713
05	SELECT	2.00E	.125	POT	37.3	0.0	99.0	0.0	0.0	98.8	0.0	2410.8	54.53	10.4750	2.788
06	SELECT	2.00E	0.25	POT	20.0	0.0	99.0	0.0	0.0	99.0	0.0	2404.3	60.30	8.9000	2.990
07	VERDICT	2.00E	.063	POT	7.5	0.0	99.0	0.0	0.0	98.8	0.0	2297.0	55.33	11.5000	2.860
08	ASSURE	0.80E	.063	POT	25.0	0.0	99.0	0.0	0.0	98.8	0.0	2386.8	55.10	10.8750	2.940
09	CULT CK		0000		25.0	0.0	52.3	0.0	0.0	50.0	0.0	2375.0	57.13	10.2750	3.005
LEAST SIGNIFICANT DIFF. (.05) =					26.74	0	16.35	0	0	7.953	0	209.9	9.101	2.133	.2711
STANDARD DEVIATION =					18.32	0	11.20	0	0	5.449	0	143.8	6.235	1.461	.1857
COEFF. OF VARIABILITY =					32.61	0	11.95	0	0	5.832	0	5.976	10.91	13.93	6.488

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NORTH CAROLINA STATE UNIVERSITY
PRE-POSTEMERGENCE HERBICIDE SCREENING FOR GRASS CONTROL IN TOBACCO

Table 13

Conducted at ROCKY MOUNT,N.C. by A.D.WORSHAM AND R.W.LEMONS
Project 86-62-RM with cooperator UPPER COASTAL PLAIN RESEARCH STATION

TRT. NUM.	PEST. NAME	FORM	RATE #ai/A	GROW. STAGE	DIGSA 6-11	ELEIN 6-11	CRINJ 6-11	DIGSA 8-7	ELEIN 8-7	CRINJ 8-7	DIGSA 9-10	ELEIN 9-10	CRINJ 9-10
01	SELECT	2.00E	.125	PBI	96.8	98.0	0.0	98.8	99.0	0.0	98.8	98.8	0.0
02	SELECT	2.00E	0.25	PBI	97.0	98.0	0.0	98.8	96.5	0.0	98.8	98.8	0.0
03	SELECT	2.00E	.125	OT	97.8	98.8	0.0	99.0	98.8	0.0	99.0	98.8	0.0
04	SELECT	2.00E	0.25	OT	99.0	98.8	0.0	99.0	98.5	0.0	99.0	98.8	0.0
05	SELECT	2.00E	.125	POT	35.0	30.0	0.0	95.8	88.8	0.0	95.3	96.5	0.0
06	SELECT	2.00E	0.25	POT	32.5	27.5	0.0	97.0	75.0	0.0	97.8	98.3	0.0
07	VERDICT	2.00E	.063	POT	32.5	30.0	0.0	98.0	80.8	0.0	99.0	97.5	0.0
08	ASSURE	0.80E	.063	POT	42.5	42.5	0.0	99.0	90.8	0.0	98.0	97.3	0.0
09	CULT CK		0000		30.0	27.5	0.0	35.0	35.0	0.0	52.5	50.0	0.0
LEAST SIGNIFICANT DIFF. (.05)=					23.94	21.04	0	12.02	18.92	0	5.325	1.451	0
STANDARD DEVIATION =					16.40	14.41	0	8.237	12.96	0	3.648	.9942	0
COEFF. OF VARIABILITY =					26.22	23.55	0	9.038	15.29	0	3.918	1.072	0

% TA(HY)
2.800
2.950
2.723
2.713
2.788
2.990
2.860
2.940
3.005
.2711
.1857
6.488

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PRE-POSTEMERGENCE HERBICIDE SCREENING FOR GRASS CONTROL IN TOBACCO

Table 14 Conducted at ROCKY MOUNT,N.C. by A.D.WORSHAM AND R.W.LEMONS
Project 86-62-RM with cooperator UPPER COASTAL PLAIN RESEARCH STATION

TRT. NUM.	PEST. NAME	FORM	RATE #ai/A	GROW. STAGE	YIELD LBS/A	GRADE INDEX	% SUGAR	% TA(HY)
01	SELECT	2.00E	.125	PBI	2082.50	42.8	18.0	2.30
02	SELECT	2.00E	0.25	PBI	2396.75	38.8	18.3	2.25
03	SELECT	2.00E	.125	OT	2357.00	38.3	17.8	2.38
04	SELECT	2.00E	0.25	OT	2419.50	36.5	16.5	2.40
05	SELECT	2.00E	.125	POT	2249.50	41.0	18.8	2.18
06	SELECT	2.00E	0.25	POT	2031.00	39.8	17.8	2.30
07	VERDICT	2.00E	.063	POT	2440.25	40.0	17.5	2.33
08	ASSURE	0.80E	.063	POT	2356.25	39.5	18.0	2.07
09	CULT CK		0000		1809.23	42.5	19.5	2.28
LEAST SIGNIFICANT DIFF. (.05) =					717.4	9.234	2.891	.3991
STANDARD DEVIATION =					491.5	6.327	1.981	.2735
COEFF. OF VARIABILITY =					21.96	15.86	11.00	12.02

NORTH CAROLINA STATE UNIVERSITY
CHARCOAL AS A PROTECTANT FROM HERBICIDE INJURY IN TOBACCO

Table 15

Conducted at CLAYTON,N.C. by A.D.WORSHAM AND R.W.LEMONS
Project 86-53-C with cooperator CENTRAL CROPS RESEARCH STATION

TRT. NUM.	PEST. NAME	FORM	RATE #ai/A	GROW. STAGE	CRINJ 6-18	CRINJ 6-25	CRINJ 7-15	HEIGHT 6-1	STAND 8-27	YIELD LB/A	QUALITY G.INDEX	% SUGAR	% TA(HY)
01 01	SCEPTER CHAR-TPW	1.50E	.125	SUR	3.3	13.3	0.0	24.87	43.7	3064.0	59.3	9.2667	2.647
02 02	SCEPTER CHAR-TPW	1.50E	.250	SUR	3.3	21.7	0.0	25.37	44.3	3104.7	61.7	10.9333	2.807
03 03	SCEPTER CHAR-TPW	1.50E	.500	SUR	3.3	18.3	0.0	25.10	45.0	3225.0	62.7	11.4000	2.663
04 04	SCEPTER CHAR-RD	1.50E	.125	SUR	5.0	25.0	1.7	23.93	45.0	3114.3	65.7	12.7333	2.647
05 05	SCEPTER CHAR-RD	1.50E	.250	SUR	16.7	30.0	6.7	20.77	47.0	3063.0	62.7	14.4000	2.503
06 06	SCEPTER CHAR-RD	1.50E	.500	SUR	15.0	30.0	8.3	21.87	43.7	3075.3	59.3	10.6000	2.720
07 07	SCEPTER CHAR-RD	1.50E	.125	OT	10.0	23.3	5.0	23.47	44.0	3156.7	65.0	10.4667	2.777
08 08	SCEPTER CHAR-RD	1.50E	.250	OT	16.7	28.3	10.0	22.30	43.3	3295.7	62.7	12.0667	2.710
09 09	SCEPTER CHAR-RD	1.50E	.500	OT	56.7	46.7	41.7	13.70	40.7	2898.0	63.3	10.0000	2.670
10 10	SCEPTER CHAR-TPW	1.50E	.125	OT	0.0	15.0	0.0	28.33	46.0	3386.0	65.0	12.7667	2.633
11 11	SCEPTER CHAR-TPW	1.50E	.250	OT	3.3	16.7	0.0	26.93	45.3	3167.3	64.0	12.5000	2.697
12 12	SCEPTER CHAR-TPW	1.50E	.500	OT	5.0	18.3	1.7	23.87	45.0	3491.7	60.3	11.7000	2.820
13 13	SCEPTER NO CHAR	1.50E	.125	SUR	28.3	30.0	13.3	23.77	43.0	3173.0	66.3	11.8333	2.783
14 14	SCEPTER NO CHAR	1.50E	.250	SUR	26.7	28.3	16.7	22.33	43.0	3117.0	61.3	10.8000	2.733
15 15	SCEPTER NO CHAR	1.50E	.500	SUR	31.7	26.7	16.7	21.93	45.0	3296.7	66.0	10.3667	2.733
16 16	SCEPTER NO CHAR	1.50E	.125	OT	40.0	45.0	18.3	20.13	43.7	3253.7	60.7	9.5333	2.757

NORTH CAROLINA STATE UNIVERSITY
CHARCOAL AS A PROTECTANT FROM HERBICIDE INJURY IN TOBACCO

Table 15 contd.

Conducted at CLAYTON,N.C. by A.D.WORSHAM AND R.W.LEMONS
Project 86-53-C with cooperator CENTRAL CROPS RESEARCH STATION

TRT. NUM.	PEST. NAME	FORM	RATE #ai/A	GROW. STAGE	CRINJ 6-18	CRINJ 6-25	CRINJ 7-15	HEIGHT 6-1	STAND 8-27	YIELD LB/A	QUALITY G.INDEX	% SUGAR	% TA(HY)
17	SCEPTER	1.50E	.250	OT	46.7	41.7	20.0	18.60	42.0	3099.7	63.3	11.2333	2.627
17	NO CHAR												
18	SCEPTER	1.50E	.500	OT	76.7	56.7	45.0	11.63	39.0	2822.3	61.3	10.8333	2.790
18	NO CHAR												
19	CULT CK		0000		1.7	6.7	0.0	28.87	47.0	3363.3	64.7	12.3000	2.647
19	CHAR-TPW												
20	CULT CK		0000		3.3	5.0	0.0	27.53	44.0	3166.3	63.0	11.1333	2.487
20	CHAR-RD												
21	CULT CK		0000		1.7	1.7	0.0	30.00	45.7	2826.7	62.0	10.5333	2.577
21	NO CHAR												
LEAST SIGNIFICANT DIFF. (.05)=					18.40	10.67	8.615	5.614	4.259	342.9	6.245	2.636	.2563
STANDARD DEVIATION =					11.15	6.467	5.221	3.402	2.581	207.8	3.784	1.597	.1553
COEFF. OF VARIABILITY =					59.29	25.70	53.48	14.72	5.858	6.595	6.019	14.13	5.781

Table 16.

Treatment

Prowl
Enide
Enide
Devrinol
Paarlan

*A Grass

**Small S

Table 16. Burley Tobacco On Farm Herbicide Tests, 1986

Treatments	Rate Lb Ai/A	Method Appl.	Ave. % Control GASCI (5 Loc)	AMBEL (3 Loc)	A.GRASS* (8 Loc)	S.BROADL** (19 Ratings)
Prowl	1.0	PPI	59	63	92	89
Enide	4.0	OT	79	61	95	82
Enide	6.0	OT	88	66	98	85
Devrinol	2.0	OT	94	63	97	80
Paarlan	1.5	PPI	60	63	88	87

*A Grass = Large crabgrass, Smooth crabgrass, Goosegrass

**Small Seeded Broadleafs = C. Lambsquarter, R. Pigweed, Carpetweed, C. Purslane

NORTH CAROLINA STATE UNIVERSITY
FERTILIZATION TEST(NO-TILL VS.CONVENTIONAL TOBACCO)

Table 17 Conducted at CLAYTON,N.C. by A.D.WORSHAM AND R.W.LEMONS
Project 86-70-C with cooperator CENTRAL CROPS RESEARCH STATION

TRT. NUM.	PEST. NAME	FORM	RATE #ai/A	GROW. STAGE	YIELD LBS/A	GRADE INDEX	% SUGAR	% TA(HY)
01	BAND			CONV	3420.5	68.08	15.80	1.818
01	40-45#N							
02	BAND			CONV	3686.5	63.93	14.58	1.870
02	60-65#N							
03	BAND			CONV	3367.8	69.55	16.20	1.743
03	80-85#N							
04	BROADCAS			CONV	3233.5	64.77	13.95	2.003
04	40-45#N							
05	BROADCAS			CONV	3456.0	66.73	14.03	1.993
05	60-65#N							
06	BROADCAS			CONV	3585.5	64.13	12.50	1.820
06	80-85#N							
07	BAND			NT	2389.8	80.90	20.90	1.527
07	40-45#N							
08	BAND			NT	2108.5	75.70	19.57	1.618
08	60-65#N							
09	BAND			NT	2989.5	74.38	18.98	1.665
09	80-85#N							
10	BROADCAS			NT	2230.0	70.38	21.80	1.348
10	40-45#N							
11	BROADCAS			NT	2405.8	81.33	19.42	1.720
11	60-65#N							
12	BROADCAS			NT	2292.3	74.63	17.35	1.763
12	80-85#N							
LEAST SIGNIFICANT DIFF. (.05)=					775.8	8.105	2.929	.3028
STANDARD DEVIATION =					537.3	5.613	2.029	.2097
COEFF. OF VARIABILITY =					18.33	7.883	11.87	12.04

NORTH CAROLINA STATE UNIVERSITY

Table 18 **FERTILIZATION TEST(NO-TILL VS.CONVENTIONAL TOBACCO)**

Conducted at CLAYTON,N.C. by A.D.WORSHAM AND R.W.LEMONS
Project 86-70-C with cooperator CENTRAL CROPS RESEARCH STATION

TRT. NUM.	PEST. NAME	FORM	RATE #ai/A	GROW. STAGE	YIELD LBS/A	GRADE INDEX		
01 01	BAND 40-45#N			CONV	3420.5	68.08		
02 02	BAND 60-65#N			CONV	3686.5	63.93		
03 03	BAND 80-85#N			CONV	3367.8	69.55	3537	66.4
04 04	BROADCAS 40-45#N			CONV	3233.5	64.77		
05 05	BROADCAS 60-65#N			CONV	3456.0	66.73		
06 06	BROADCAS 80-85#N			CONV	3585.5	64.13		
07 07	BAND 40-45#N			NT	2389.8	80.90		
08 08	BAND 60-65#N			NT	2108.5	75.70		
09 09	BAND 80-85#N			NT	2989.5	74.38	2292	76.4
10 10	BROADCAS 40-45#N			NT	2230.0	70.38		
11 11	BROADCAS 60-65#N			NT	2405.8	81.33		
12 12	BROADCAS 80-85#N			NT	2292.3	74.63		
LEAST SIGNIFICANT DIFF. (.05)=					775.8	8.105	196	3.35
STANDARD DEVIATION =					537.3	5.613		
COEFF. OF VARIABILITY =					18.33	7.883	12	8

NORTH CAROLINA STATE UNIVERSITY
HERBICIDE EVALUATION IN NO-TILL FLUE-CURED TOBACCO

Table 19

Conducted at CLAYTON,N.C. by A.D.WORSHAM AND R.W.LEMONS
Project 8o-54-C with cooperator CENTRAL CROPS RESEARCH STATION

TRT. NUM.	PEST. NAME	FORM	RATE #ai/A	GROW. STAGE	APPLOVER 5-16	DIGSA 6-20	AMARE 6-20	CHEAL 6-20	CRINJ 6-20	DIGSA 7-25	AMARE 7-25	CHEAL 7-25	CRINJ 7-25	YIELD #/G.WT
01	IGNITE	1.67E	1.00	GKTM	8.3	96.0	50.0	43.3	8.3	73.3	40.0	40.0	0.0	7.933
01	ENIDE	0.90W	3.00	GKTM										
01	ENIDE	0.90W	3.00	OT										
02	PARAQUAT	2.00E	0.50	GKTM	8.3	95.3	55.0	66.0	1.7	76.7	43.3	50.0	0.0	9.367
02	ENIDE	0.90W	3.00	GKTM										
02	ENIDE	0.90W	3.00	OT										
03	PARAQUAT	2.00E	0.50	GKTM	6.7	90.3	66.0	79.3	13.3	81.7	75.0	76.7	0.0	13.133
03	COMMAND	6.00E	0.62	GKTM										
03	COMMAND	6.00E	0.62	OT										
04	PARAQUAT	2.00E	0.50	GKTM	13.3	65.0	97.3	98.3	13.3	60.0	93.3	86.7	13.3	11.933
04	SCEPTER	1.50E	0.06	GKTM										
04	SCEPTER	1.50E	0.06	OT										
05	PARAQUAT	2.00E	0.50	GK	5.0	89.3	98.3	98.3	3.3	91.7	97.0	97.0	1.7	14.367
05	COMMAND	6.00E	0.75	OTTM										
05	SCEPTER	1.50E	0.06	OTTM										
06	PARAQUAT	2.00E	0.50	GK	16.7	97.7	63.0	86.3	1.7	92.7	71.7	85.0	0.0	14.133
06	COMMAND	6.00E	1.25	OT										
07	PARAQUAT	2.00E	0.50	GK	21.7	55.0	98.7	98.7	36.7	40.0	94.3	93.3	26.7	14.600
07	SCEPTER	1.50E	.125	OT										
08	PARAQUAT	2.00E	0.50	GK	10.0	63.3	61.7	63.3	8.3	43.3	56.7	56.7	0.0	10.833
08	ENIDE	0.90W	6.00	OT										
09	PARAQUAT	2.00E	0.50	GK	25.0	88.7	88.0	92.3	5.0	76.7	80.0	78.3	0.0	13.133
09	DEVRINOL	2.00E	1.00	OT										
10	PARAQUAT	2.00E	0.50	GK	16.7	16.7	16.7	20.0	0.0	0.0	0.0	0.0	0.0	5.583
LEAST SIGNIFICANT DIFF. (.05) =					12.42	21.80	35.15	29.92	13.93	17.92	15.65	12.83	13.64	3.233
STANDARD DEVIATION =					7.245	12.71	20.49	17.44	6.375	10.44	9.131	7.483	7.952	1.884
COEFF. OF VARIABILITY =					55.03	16.73	29.50	23.38	69.55	16.42	14.01	11.27	190.8	16.38

Table 20

Conducte
Project
STATION

TRT. NUM.	VA
01	K3
02	NF--
03	C3
04	NF-.
05	G7
06	NC8
07	C37

LSI
%

2000269992

Table 20

NORTH CAROLINA STATE UNIVERSITY
NO-TILL TOBACCO VARIETY EVALUATION

Conducted at Rocky Mount, N.C. by A.D.WORSHAM AND R.W.LEMONS
Project 86-78-C with cooperator CENTRAL CROPS RESEARCH STATION

TRT. NUM.	VARIETY	YIELD LBS/A	GRADE INDEX	% SUGAR	% TA(HY)
01	K326	2675	73.6	18.6	1.60
02	NF-28	2813	76.6	18.3	1.68
03	C319	2181	72.4	18.9	1.62
04	NF-22	2582	68.4	16.9	2.06
05	G70	2518	68.9	19.9	1.50
06	NC82	2404	75.4	19.9	1.45
07	C373	2574	69.3	17.6	1.71
	LSD. .05	NS	NS	NS	.33
	% C.V.	17	6	9.7	12

2000269993

Table 21. No-tillage flue cured tobacco yields and quality with and without sidedress nitrogen, Clayton, NC 1986.

Cover Crop	Sidedress (N) (lbs/A)	Yield (lbs/A)	Grade Index
Crimson Clover	0	2685 bc	74
Crimson Clover	30	2915 b	67
Hairy Vetch	0	3178 a	69
Hairy Vetch	30	3254 a	67
Rye + CC	0	2106 d	70
Rye + CC	30	2618 c	64
Rye + HV	0	2344 d	74
Rye + HV	30	2921 a	69
		FLSD(.05)	-—

Table 22. No-tillage flue cured tobacco yields and quality with recommended fertility practices, Clayton and Rocky Mount, NC 1986.

Cover Crop	Yield (lbs/A)		Grade Index	
	Clayton	Rocky Mount	Clayton	Rocky Mount
Rye (1.5 bu/A)	2412 c	1861	67	41
Rye (6.0 bu/A)	2573 c	1826	65	42
Crimson Clover	2915 b	2167	66	37
Hairy Vetch	3254 a	2182	67	43
Rye + CC	2618 c	1940	64	39
Rye + HV	2921 b	2089	69	36
Conventional	3278 a	1985	70	40
	FLSD (0.5)	NS		

NORTH CAROLINA STATE UNIVERSITY
BURLEY TOBACCO HERBICIDE EVALUATION(NO-TILL VS CONV)

Table 23. Conducted at WAYNESVILLE,N.C. by A.D.WORSHAM AND R.W..EHONS
Project 86-72-W with cooperator MOUNTIAN RESEARCH STATION

TRT. NUM.	PEST. NAME	FORM	RATE #ai/A	GROW. STAGE	DIGSA 6-24-87	CRINJ 6-24-87	DIGSA 8-24-87	CRINJ 8-24-87	YIELD LBS/A
01	PARAQUAT	2.00E	0.50	GK	96.8	0.0	91.0	0.0	2994.5
01	ENIDE	0.90W	6.00	OT					
02	PARAQUAT	2.00E	0.50	GK	97.8	0.0	93.3	0.0	2877.0
02	DEVRINOL	2.00E	1.00	OT					
03	PARAQUAT	2.00E	0.50	GK	94.5	6.3	90.0	0.0	3226.3
03	SCEPTER	1.50E	.125	OT					
04	PARAQUAT	2.00E	0.50	GK	99.0	0.0	99.0	0.0	3373.5
04	COMMAND	6.00E	1.00	OT					
05	PARAQUAT	2.00E	0.50	GK	96.8	1.3	96.8	0.0	2791.5
05	ENIDE	0.90W	6.00	OT					
05	SCEPTER	1.50E	1.25	POT					
05	SELECT	2.00E	0.25	POT					
06	PARAQUAT	2.00E	0.50	GK	60.0	0.0	57.3	0.0	2848.8
07	ENIDE	0.90W	6.00	OT	96.0	0.0	90.0	0.0	3061.8
08	DEVRINOL	2.00E	1.00	OT	95.5	0.0	91.3	0.0	2617.3
09	SCEPTER	1.50E	.125	OT	92.3	11.3	87.5	0.0	2910.5
10	COMMAND	6.00E	1.00	OT	98.8	0.0	98.5	0.0	2517.5
11	ENIDE	0.90W	6.00	OT	96.3	0.0	97.5	0.0	2887.5
11	SCEPTER	1.50E	.125	POT					
11	SELECT	2.00E	0.25	POT					
12	CULT CK*		0000		42.5	0.0	45.0	0.0	2684.8
LEAST SIGNIFICANT DIFF. (.05) =					9.128	2.358	14.09	0	652.5
STANDARD DEVIATION =					6.322	1.633	9.758	0	451.9
COEFF. OF VARIABILITY =					7.116	104.5	11.29	0	15.58

*Temporary chlorosis of leaves in early-season

APPENDIX

EXPERIMENT DESCRIPTION FORM

NORTH CAROLINA STATE UNIVERSITY

HERBICIDE EVALUATION IN FLUE-CURED TOBACCO

Conducted at KINSTON,N.C. by A.D.WORSHAM AND R.W.LEMONS
Project 86-59-K with cooperator LOWER COASTAL PLAIN TOBACCO RESEARCH STATION

Experimental Management

Date Planted 4-16-86 Variety K 326 Row Width 45"
Design RANDOMIZED COMPLETE BLOCK No. Reps. 4 Plot Size 2 ROWS X 45 FT.
Field Preparation and Plot Maintenance CHISEL,DISK AND BEDDED.ALL PLOTS WERE CULTIVATED TWICE DURING THE GROWING SEASON.

Site Description

Season Moisture DRY
Soil Texture SANDY LOAM % Sand _______ % Silt _______ % Clay _______
Soil Series NORFOLK % OM .9 pH 6.0 CEC _______

Application Information

	1	2	3	4	5	6
Date Treated	4-9-86	4-17-86	4-17-86			
Time Treated	AM	PM	PM			
Cloud Cover	20	100	100			
Air Temperature	62	55	55			
Relative Humidity						
Wind Speed/Direction	10-20NE	15NE	15NE			
Soil Temperature	70	60	60			
Soil/Leaf Surface Moisture	DRY	GOOD	GOOD			
Soil Subsurface Moisture	DRY	GOOD	GOOD			
Soil Tilth						
Crop Stage	PBI	OT	BAN			
Pest Name, Stage & Density						

Application Equipment

	Sprayer Type	Speed MPH	Nozzle Type	Nozzle Size	Nozzle Height	Nozzle Spacing	Boom Width	GPA	Carrier	PSI
1.	CO2 BACKPACK	3	MONARCH	49X49	8"	20"	100"	19.1	H2O	20
2.	CO2 BACKPACK	3	MONARCH	49X49	8"	20"	100"	19.1	H2O	20
3.	CO2 BACKPACK	3	MONARCH	49X49	8"	20"	40"	19.1	H2O	20
4.										
5.										
6.										

Comments

PBI DOUBLE-DISKED INCORPORATED 4"-6"

EXPERIMENT DESCRIPTION FORM

NORTH CAROLINA STATE UNIVERSITY

HERBICIDE EVALUATION IN FLUE-CURED TOBACCO

Conducted at REIDSVILLE,N.C. by A.D.WORSHAM AND R.W.LEMONS
Project 86-60-RD with cooperator UPPER PIEDMONT RESEARCH STATION

Experimental Management

Date Planted 5-20-86 Variety NC82 Row Width 48"
Design RANDOMIZED COMPLETE BLOCK No. Reps. 3 Plot Size 2 ROWSX45 FT.
Field Preparation and Plot Maintenance PLOWED,DISKED AND BEDDED.ALL PLOTS WERE CULTIVATED TWICE DURING THE GROWING SEASON.

Site Description

Season Moisture DRY
Soil Texture CLAY LOAM % Sand _______ % Silt _______ % Clay _______
Soil Series DUNBAR % OM .8 pH 5.9 CEC _______

Application Information

	1	2	3	4	5	6
Date Treated	5-6-86	5-29-86	5-29-86			
Time Treated	PM	AM PM	PM			
Cloud Cover	0	50	50			
Air Temperature	85	79	82			
Relative Humidity						
Wind Speed/Direction	0-3SE	3-5NE	3-5NE			
Soil Temperature	83	75	75			
Soil/Leaf Surface Moisture	DRY	DAMP	DAMP			
Soil Subsurface Moisture	DRY	DAMP	DAMP			
Soil Tilth						
Crop Stage	PBI	OT	BAN			
Pest Name, Stage & Density						

Application Equipment

	Sprayer Type	Speed MPH	Nozzle Type	Nozzle Size	Nozzle Height	Nozzle Spacing	Boom Width	GPA	Carrier	PSI
1.	CO2 BACKPACK	3	MONARCH	49X49	8"	20"	100"	19.1	H2O	20
2.	CO2 BACKPACK	3	MONARCH	49X49	8"	20"	100"	19.1	H2O	20
3.	CO2 BACKPACK	3	MONARCH	49X49	8"	20"	40"	19.1	H2O	20
4.										
5.										
6.										

Comments

PBI DOUBLE-DISKED INCORPORATED 4"-6"

EXPERIMENT DESCRIPTION FORM

NORTH CAROLINA STATE UNIVERSITY

HERBICIDE EVALUATION IN FLUE-CURED TOBACCO

Conducted at ROCKY MOUNT, N.C. by A.D.WORSHAM AND R.W.LEMONS
Project 86-64-RM with cooperator UPPER COASTAL PLAIN RESEARCH STATION

Experimental Management

Date Planted 5-11-86 Variety MCNAIR 944 Row Width 45"
Design RANDOMIZED COMPLETE BLOCK No. Reps. 3 Plot Size 2 ROWSX 45 FT.
Field Preparation and Plot Maintenance CHISEL,DISKED AND BEDDED.ALL PLOTS WERE CULTIVATED TWICE DURING THE GROWING SEASON.

Site Description

Season Moisture SEE RAINFALL TABLES
Soil Texture SANDY LOAM % Sand _______ % Silt _______ % Clay _______
Soil Series NORFOLK % OM 1.1 pH 6.0 CEC _______

Application Information

	1	2	3	4	5	6
Date Treated	5-12	6-2	6-25			
Time Treated	PM	PM	PM			
Cloud Cover	0	0	0			
Air Temperature	64	90	92			
Relative Humidity						
Wind Speed/Direction	5-10SW	3-5SW	0-3SW			
Soil Temperature	60	85	82			
Soil/Leaf Surface Moisture	FAIR		DRY			
Soil Subsurface Moisture	FAIR		DRY			
Soil Tilth						
Crop Stage	OT	POT	LBY			
Pest Name, Stage & Density						

Application Equipment

	Sprayer Type	Speed MPH	Nozzle Type	Nozzle Size	Nozzle Height	Nozzle Spacing	Boom Width	GPA	Carrier	PSI
1.	+02 BACKPACK	3	MONARCH	49X49	8"	20"	100"	19.1	H2O	20
2.	CO2 BACKPACK	3	MONARCH	49X49	8"	20"	80"	18.1	H2O	20
3.	CO2 BACKPACK	3	MONARCH	49X49	8"	20"	40"	19.1	H2O	20
4.										
5.										
6.										

Comments

ALL POT TREATMENTS HAD CONTAMINATION FROM SPRAYER(PROBABLY FROM CORN HERBICIDE).

EXPERIMENT DESCRIPTION FORM

NORTH CAROLINA STATE UNIVERSITY

HERBICIDE EVALUATION IN FLUE-CURED TOBACCO

Conducted at CLAYTON,N.C. by A.D.WORSHAM AND R.W.LEMONS
Project 86-79-C with cooperator CENTRAL CROPS RESEARCH STATION

Experimental Management

Date Planted 5-5-86 Variety COKER 373 Row Width 45"
Design RANDOMIZED COMPLETE BLOCK No. Reps. 4 Plot Size 2 ROWSX 45 FT.
Field Preparation and Plot Maintenance SUB-SOILED,DISKED AND BEDDED

Site Description

Season Moisture SEE RAINFALL TABLES
Soil Texture SANDY LOAM % Sand ______ % Silt ______ % Clay ______
Soil Series GOLDSBORO % OM 1.0 pH 6.0 CEC ______

Application Information

	1	2	3	4	5	6
Date Treated	5-5	5-28	6-22			
Time Treated	PM	PM	PM			
Cloud Cover	5	0	0			
Air Temperature	82	85	87			
Relative Humidity						
Wind Speed/Direction	10-20SW	0-3NE	0			
Soil Temperature	82	82	85			
Soil/Leaf Surface Moisture	DRY	DRY	DRY			
Soil Subsurface Moisture	DRY	DRY	DRY			
Soil Tilth						
Crop Stage	OT	POT	LBY			
Pest Name, Stage & Density						

Application Equipment

	Sprayer Type	Speed MPH	Nozzle Type	Nozzle Size	Nozzle Height	Nozzle Spacing	Boom Width	GPA	Carrier	PSI
1.	CO2 BACKPACK	3	MONARCH	49X49	8"	20"	100"	19.1	H2O	20
2.	CO2 BACKPACK	3	MONARCH	49X49	8"	20"	100"	19.1	H2O	20
3.	CO2 BACKPACK	3	MONARCH	49X49	8"	20"	40"	19.1	H2O	20
4.										
5.										
6.										

Comments

2000270000

EXPERIMENT DESCRIPTION FORM

NORTH CAROLINA STATE UNIVERSITY

EVALUATION OF DEVRINOL IMPREGNATED ON FERTILIZER IN TOBACCO

Conducted at ROCKY MOUNT, N.C. by A.D.WORSHAM AND R.W.LEMONS
Project 86-51-RM with cooperator UPPER COASTAL PLAIN RESEARCH STATION

Experimental Management

Date Planted 5-11-1986 Variety MCNAIR 944 Row Width 48"
Design RANDOMIZED COMPLETE BLOCK No. Reps. 4 Plot Size 3 ROWSX45 FT.
Field Preparation and Plot Maintenance CHISELED, DISKED AND BEDDED.

Site Description

Season Moisture SEE RAINFALL TABLES
Soil Texture SANDY LOAM % Sand ____ % Silt ____ % Clay ____
Soil Series NORFOLK % OM 1.1 pH 6.0 CEC ____

Application Information

	1	2	3	4	5	6
Date Treated	4-24	4-28				
Time Treated	PM	PM				
Cloud Cover	0	0				
Air Temperature	62	82				
Relative Humidity						
Wind Speed/Direction	10-15NE	3-5NE				
Soil Temperature	60	70				
Soil/Leaf Surface Moisture	DRY	DRY				
Soil Subsurface Moisture	FAIR	DRY				
Soil Tilth						
Crop Stage	PBI	SUR				
Pest Name, Stage & Density						

Application Equipment

	Sprayer Type	Speed MPH	Nozzle Type	Nozzle Size	Nozzle Height	Nozzle Spacing	Boom Width	GPA	Carrier	PSI
1.	CO2 BACKPACK	3	MONARCH	49X49	8"	20"	100"	19.1	H2O	20
2.	CO2 BACKPACK	3	MONARCH	49X49	8"	20"	100"	19.1	H2O	20
3.										
4.										
5.										
6.										

Comments

ON-FERT. TREATMENTS WERE APPIED BROADCAST. FERTILIZER RATE WAS 15-0-14 200#/A FOR INPREGNATED TREATMENTS.

Harvest Dates - A = 7-31-86, B = 8-14-86, C = 8-29-86, D = 9-2-86

Sample Date - Oct. 21, 1986 Composite made from 4 primings and 4 reps

EXPERIMENT DESCRIPTION FORM

NORTH CAROLINA STATE UNIVERSITY

EVALUATION OF DEVRINOL IMPREGNATED ON FERTILIZER IN TOBACCO

Conducted at WAYNESVILLE,N.C. by A.D.WORSHAM AND R.W.LEMONS
Project 86-52-W with cooperator MOUNTIAN RESEARCH STATION

Experimental Management

Date Planted 6-2-86 Variety TN86 Row Width 48"
Design RANDOMIZED COMPLETE BLOCK No. Reps. 4 Plot Size 2 ROWSX 33 FT.
Field Preparation and Plot Maintenance PLOWED AND DISKED.

Site Description

Season Moisture DRY(SEE RAINFALL TABLES)
Soil Texture CLAY LOAM % Sand ______ % Silt ______ % Clay ______
Soil Series DYKE % OM 1.2 pH 6.2 CEC ______

Application Information

	1	2	3	4	5	6
Date Treated	5-26	5-26				
Time Treated	PM	PM				
Cloud Cover	100	100				
Air Temperature	70	70				
Relative Humidity						
Wind Speed/Direction	3-5SW	3-5SW				
Soil Temperature	69	69				
Soil/Leaf Surface Moisture	DRY	DRY				
Soil Subsurface Moisture	GOOD	GOOD				
Soil Tilth						
Crop Stage	PBI	SUR				
Pest Name, Stage & Density						

Application Equipment

	Sprayer Type	Speed MPH	Nozzle Type	Nozzle Size	Nozzle Height	Nozzle Spacing	Boom Width	GPA	Carrier	PSI
1.	CO2 BACKPACK	3	MONARCH	49X49	8"	20"	100"	19.1	H20	20
2.	CO2 BACKPACK	3	MONARCH	49X49	8"	20"	100"	19.1	H20	20
3.										
4.										
5.										
6.										

Comments

FERTILIZER WAS APPIED AT THE RATE OF 2000#/A OF 8-8-8.

EXPERIMENT DESCRIPTION FORM

NORTH CAROLINA STATE UNIVERSITY

PRE-POSTEMERGENCE HERBICIDE SCREENING FOR GRASS CONTROL IN TOBACCO

Conducted at KINSTON,N.C. by A.D.WORSHAM AND R.W.LEMONS
Project 86-61-K with cooperator LOWER COASTAL PLAIN TOBACCO RESEARCH STATION

Experimental Management

Date Planted 4-16-86 Variety K326 Row Width 45"
Design RANDOMIZED COMPLETE BLOCK No. Reps. 4 Plot Size 2 ROWS BY 45 FT.
Field Preparation and Plot Maintenance CHISEL,DISK AND BEDDED

Site Description

Season Moisture DRY
Soil Texture ______ % Sand ______ % Silt ______ % Clay ______
Soil Series ______ % OM ______ pH ______ CEC ______

Application Information

	1	2	3	4	5	6
Date Treated	4-9-86	4-17-86	6-4-86			
Time Treated						
Cloud Cover	20	100	0			
Air Temperature	62	55	82			
Relative Humidity						
Wind Speed/Direction	10-20NE	15NE	5-10NE			
Soil Temperature	70	60	75			
Soil/Leaf Surface Moisture						
Soil Subsurface Moisture	DRY	GOOD	DRY			
Soil Tilth						
Crop Stage	PBI	OT	POT			
Pest Name, Stage & Density			DIGSA <1/SQ.FT 1-2"			

Application Equipment

	Sprayer Type	Speed MPH	Nozzle Type	Nozzle Size	Nozzle Height	Nozzle Spacing	Boom Width	GPA	Carrier	PSI
1.	CO2 BACKPACK	3	MONARCH	49x49	8"	20"	100"	19.1	H2O	20
2.	CO2 BACKPACK	3	MONARCH	49x49	8"	20"	100"	19.1	H2O	20
3.	CO2 BACKPACK	3	MONARCH	49x49	8"	20"	100"	19.1	H2O	20
4.										
5.										
6.										

Comments

PBI DOUBLE-DISKED INCORPORATED 4"-6"
AFTER 5/28, EVALUATION DATE ALL TREATMENTS WERE CULTIVATED TWICE.

2000270003

EXPERIMENT DESCRIPTION FORM

NORTH CAROLINA STATE UNIVERSITY

CHARCOAL AS A PROTECTANT FROM HERBICIDE INJURY IN TOBACCO

Conducted at CLAYTON,N.C. by A.D.WORSHAM AND R.W.LEMONS
Project 86-53-C with cooperator CENTRAL CROPS RESEARCH STATION

Experimental Management

Date Planted 5-13-86 Variety C-373 Row Width 45"
Design RANDOMIZED STRIP BLOCK No. Reps. 3 Plot Size 2 ROWS X 45 FT.
Field Preparation and Plot Maintenance SUB-SOIL,DISK AND BEDDED.SURFACE TREATMENTS WERE KNOCKOFF AS IF TRANSPLANTED BEFORE APPICATION.

Site Description

Season Moisture DRY
Soil Texture SANDY LOAM % Sand _______ % Silt _______ % Clay _______
Soil Series WAGRAM AND GOLDSBORO % OM .9-1.2 pH 6.0 CEC _______

Application Information

	1	2	3	4	5	6
Date Treated	5-13-86	5-13-86				
Time Treated	AM	PM				
Cloud Cover	0	0				
Air Temperature	80	85				
Relative Humidity						
Wind Speed/Direction	0-3NE	3-5NE				
Soil Temperature	72	76				
Soil/Leaf Surface Moisture						
Soil Subsurface Moisture	DRY	DRY				
Soil Tilth						
Crop Stage	SURFACE	OVERTOP				
Pest Name, Stage & Density						

Application Equipment

	Sprayer Type	Speed MPH	Nozzle Type	Nozzle Size	Nozzle Height	Nozzle Spacing	Boom Width	GPA	Carrier	PSI
1.	CO2 BACKPACK	3	MONARCH	49X49	8"	20"	100"	19.1	H20	20
2.	CO2 BACKPACK	3	MONARCH	49X49	8"	20"	100"	19.1	H20	20
3.										
4.										
5.										
6.										

Comments

GRANULATED CHARCOAL USED AS A ROOT DIP 1#/1.5 GAL. H20 PLUS 100 cc.X-77 SURFACTANT.
GRANULATED CHARCOAL USED IN THE TRANSPLANT WATER AT THE RATE OF 1#/55 GALS.PLUS 100 cc.X-77 SURFACTANT.APPROXIMATELY 400 GALS. OF WATER/ACRE WAS USED IN THE TRANSPLANT OPERATION.
WE DIPPED APPROXIMATELY 2000 PLANTS WITH THE 1.5 GALS. MIXTURE.
THE CHARCOAL IN THE TRANSPLANT WATER STAYED IN SUSPENSION WELL WITHOUT AGITATION

EXPERIMENT DESCRIPTION FORM

NORTH CAROLINA STATE UNIVERSITY

FERTILIZATION TEST(NO-TILL VS.CONVENTIONAL TOBACCO)

Conducted at CLAYTON,N.C. by A.D.WORSHAM AND R.W.LEMONS
Project 86-70-C with cooperator CENTRAL CROPS RESEARCH STATION

Experimental Management

Date Planted 5-14-86 Variety K326 Row Width 45"
Design RANDOMIZED COMPLETE BLOCK No. Reps. 4 Plot Size 2 ROWX 45 FT.
Field Preparation and Plot Maintenance NO-TILL=CHISEL,DISKED,BEDDED AND RYE COVER SOWN IN FALL.CONVENTIONAL=CHISEL,DISKED AND BEDDED IN SPRING.

Site Description

Season Moisture SEE RAINFALL TABLES
Soil Texture LOAMY SAND % Sand _______ % Silt _______ % Clay _______
Soil Series DOTHAN % OM .9 pH 6.2 CEC _______

Application Information

	1	2	3	4	5	6
Date Treated	4-8-86	5-16-86				
Time Treated	AM	PM				
Cloud Cover	50	30				
Air Temperature	75	75				
Relative Humidity						
Wind Speed/Direction	5-15NE	0				
Soil Temperature	68	70				
Soil/Leaf Surface Moisture	DRY	DRY				
Soil Subsurface Moisture	DRY	GOOD				
Soil Tilth						
Crop Stage	GRAINKIL	OT				
Pest Name, Stage & Density						
RYE COVER	4-5 FT.					

Application Equipment

	Sprayer Type	Speed MPH	Nozzle Type	Nozzle Size	Nozzle Height	Nozzle Spacing	Boom Width	GPA	Carrier	PSI
1.	CO2 BACKPACK	3	MONARCH	49X49	20"	20"	100"	19.1	H2O	20
2.	CO2 BACKPACK	3	MONARCH	49X49	20"	20"	100"	19.1	H2O	20
3.										
4.										
5.										
6.										

Comments

BROADCAST FERTILIZER(6-6-18) APPLIED ON APRIL 30,1986.BAND FERTILIZER(6-6-18) APPLIED ON MAY 15,1986.

EXPERIMENT DESCRIPTION FORM

NORTH CAROLINA STATE UNIVERSITY

HERBICIDE EVALUATION IN NO-TILL FLUE-CURED TOBACCO

Conducted at CLAYTON,N.C. by A.D.WORSHAM AND R.W.LEMONS
Project 86-54-C with cooperator CENTRAL CROPS RESEARCH STATION

Experimental Management

Date Planted 5-15-1986 Variety K326 Row Width 45"
Design RANDOMIZED COMPLETE BLOCK No. Reps. 3 Plot Size 2 ROWS X 45 FT.
Field Preparation and Plot Maintenance SUB-SOILED,DISKED AND BEDDED IN FALL.BEDS KNOCKED OFF.RYE SOWN AND COVERED FOR NO-TILL MULCH.

Site Description

Season Moisture SEE RAINFALL TABLES
Soil Texture SANDY LOAM % Sand ______ % Silt ______ % Clay ______
Soil Series WAGRAM AND GOLDSBORO % OM 1-1.3 pH 6.0 CEC ______

Application Information

	1	2	3	4	5	6
Date Treated	4-8-1986	5-16				
Time Treated	PM	PM				
Cloud Cover	50	30				
Air Temperature	75	75				
Relative Humidity						
Wind Speed/Direction	5-10SW	0				
Soil Temperature	68	70				
Soil/Leaf Surface Moisture	DRY	DRY				
Soil Subsurface Moisture	DRY	GOOD				
Soil Tilth						
Crop Stage	GRAINKIL OT					
Pest Name, Stage & Density						
RYE	4-6 FT.					

Application Equipment

	Sprayer Type	Speed MPH	Nozzle Type	Nozzle Size	Nozzle Height	Nozzle Spacing	Boom Width	GPA	Carrier	PSI
1.	CO2 BACKPACK	3	MONARCH	49X49	15"	20"	100"	19.1	H2O	20
2.	CO2 BACKPACK	3	MONARCH	49X49	8"	20"	100"	19.1	H2O	20
3.										
4.										
5.										
6.										

Comments

FIRST RATING INCIDICATES AMOUNT OF WEEDS PRESENT AT OVERTOP APPLICATION.YIELD IS GREEN LEAF WEIGHT IN LBS./6 PLANTS.

EXPERIMENT DESCRIPTION FORM

NORTH CAROLINA STATE UNIVERSITY

NO-TILL TOBACCO VARIETY EVALUATION

Conducted at CLAYTON,N.C. by A.D.WORSHAM AND R.W.LEMONS
Project 86-78-C with cooperator CENTRAL CROPS RESEARCH STATION

Experimental Management

Date Planted 5-14-86 Variety SEE TREATMENT PAGE Row Width 45"
Design RANDOMIZED COMPLETE BLOCK No. Reps. 4 Plot Size 2 ROES BY 45 FT.
Field Preparation and Plot Maintenance NO-TILL=CHISEL,DISKED,BEDDED AND RYE COVER SOWN IN FALL.CONVENTIONAL=CHISEL,DISKED AND BEDDED IN SPRING.

Site Description

Season Moisture SEE RAINFALL TABLES
Soil Texture LOAMY SAND % Sand _______ % Silt _______ % Clay _______
Soil Series DOTHAN % OM .9 pH 6.2 CEC _______

Application Information

	1	2	3	4	5	6
Date Treated	4-8-86	5-16-86				
Time Treated	AM	PM				
Cloud Cover	50	30				
Air Temperature	75	75				
Relative Humidity						
Wind Speed/Direction	5/15 NE	0				
Soil Temperature	68	70				
Soil/Leaf Surface Moisture	DRY	DRY				
Soil Subsurface Moisture	DRY	GOOD				
Soil Tilth						
Crop Stage	GRAINKIL 01					
Pest Name, Stage & Density						
RYE COVER	4-5 FT.					

Application Equipment

	Sprayer Type	Speed MPH	Nozzle Type	Nozzle Size	Nozzle Height	Nozzle Spacing	Boom Width	GPA	Carrier	PSI
1.	CO2 BACKPACK	3	MONARCH	49X49	20"	20"	100"	19.1	H2O	20
2.	CO2 BACKPACK	3	MONARCH	49X49	20"	20"	100"	19.1	H2O	20
3.										
4.										
5.										
6.										

Comments

BAND FERTILIZER (6-6-18) APPLIED ON MAY 15,1986 ,SIDEDRESSED ABOUT 2 WEEKS LATER BOTH TOTALING 65 LBS NITROGEN PER ACRE.

EXPERIMENT DESCRIPTION FORM

NORTH CAROLINA STATE UNIVERSITY

BURLEY TOBACCO HERBICIDE EVALUATION(NO-TILL VS CONV)

Conducted at WAYNESVILLE,N.C. by A.D.WORSHAM AND R.W.LEMONS
Project 86-72-W with cooperator MOUNTIAN RESEARCH STATION

Experimental Management

Date Planted 5-28-86   Variety TN 86   Row Width 48"
Design RSBD   No. Reps. 4   Plot Size 2 ROWS X 33 FT.
Field Preparation and Plot Maintenance NO-TILL =CHISEL,DISKED AND RYE SOWN IN FALL. CONVENTIONAL=CHISEL AND DISKED IN SPRING.

Site Description

Season Moisture SEE RAINFALL TABLES
Soil Texture CLAY   % Sand ______ % Silt ______ % Clay ______
Soil Series DYKE   % OM .9   pH 6.2   CEC ______

Application Information

	1	2	3	4	5	6
Date Treated	5-7-86	5-29-87	8-5-86			
Time Treated	PM	PM	PM			
Cloud Cover	0	0	0			
Air Temperature	75	70	65			
Relative Humidity						
Wind Speed/Direction	0	0-3NE	0			
Soil Temperature		68	78			
Soil/Leaf Surface Moisture		WET	DRY			
Soil Subsurface Moisture		WET	DRY			
Soil Tilth						
Crop Stage	BK	OT	PUT			
Pest Name, Stage & Density						
RYE	4-5 FT.					

Application Equipment

	Sprayer Type	Speed MPH	Nozzle Type	Nozzle Size	Nozzle Height	Nozzle Spacing	Boom Width	GPA	Carrier	PSI
1.	CO2 BACKPACK	3	MONARCH	49X49	8"	20"	100"	19.1	H2O	20
2.	CO2 BACKPACK	3	MONARCH	49X49	8"	20"	100"	19.1	H2O	20
3.	CO2 BACKPACK	3	MONARCH	49X49	8"	20"	40"	19.1	H2O	20
4.										
5.										
6.										

Comments

Irrigation Information

Locations and Experiment	Dates	Amounts (inches)
Clayton		
Fertilization Test	5-12	1.0
No-till Variety Eval.	6-25	1.0
No-till Lugume Study	7-9	1.0
	7-15	.75
		3.75
Herbicide Eval. in No-till	6-24	1.0
Charcoal as a Protectant	7-11	.75
	7-18	.75
	7-22	.50
		3.0
Herbicide Eval.-3	5-7	1.0
	6-24	1.0
	7-11	.75
	7-18	.75
		3.5
Reidsville		
Herbicide Eval. -1	6-18	.50
	7-10	1.0
	7-18	1.5
		3.0
Rocky Mount		
All Experiments	4-10	1.25
	5-12	1.0
	6-26	1.5
	7-18	1.5
	7-29	2.4
		7.65
Waynesville		
No-till vs Conv.	7-10	1.0
Devrinol Impregnated	7-10	1.0
	8-4	1.0
		2.0
Kinston	No Irrigation Available	

RAINFALL

Upper Piedmont Research Station

Reidsville, NC 1986

Date	April	May	June	July	August
1	0	0	0	.28	0
2	0	0	0	.74	0
3	0	0	0	.49	.51
4	0	0	0	0	0
5	0	0	0	0	1.04
6	0	0	0	0	0
7	.03	0	0	0	0
8	0	0	0	0	.09
9	.05	0	0	0	0
10	0	0	0	0	0
11	0	0	0	.27	0
12	0	0	0	.04	4.19
13	0	.19	0	0	.44
14	0	.77	0	0	0
15	0	.02	0	0	0
16	.39	0	0	0	0
17	0	0	0	0	0
18	0	0	0	0	.02
19	0	.10	0	0	.25
20	0	1.02	0	0	.87
21	.15	.22	0	0	.75
22	0	0	0	0	.05
23	0	0	0	.50	0
24	0	.04	.24	0	.20
25	0	0	0	0	0
26	.24	0	0	0	0
27	0	.19	0	.51	0
28	0	.03	0	0	.08
29	0	.24	.77	0	.19
30	0	0	.05	0	0
31		.28		0	0
Total	.86	3.10	1.06	2.83	8.68

Date
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
Total

ugust
0
0
.51
0
1.04
0
0
.09
0
0
0
4.19
.44
0
0
0
0
.02
.25
.87
.75
.05
0
.20
0
0
0
.08
.19
0
0
8.68

RAINFALL

Central Crops Research Station

Clayton, NC 1986

Date	April	May	June	July	August
1	0	0	0	.45	0
2	0	0	.20	.46	.79
3	0	0	0	0	.41
4	0	0	0	0	.01
5	0	0	0	0	0
6	.07	0	0	0	0
7	0	0	.15	0	0
8	.12	0	.19	0	0
9	0	0	0	.01	0
10	0	0	0	.03	.29
11	0	0	0	.02	1.00
12	0	0	0	.10	.54
13	0	0	0	0	.43
14	0	0	0	0	0
15	0	0	.02	0	0
16	.09	0	.14	0	.26
17	.01	0	0	0	.05
18	0	0	0	0	.89
19	0	.89	0	0	.54
20	0	.09	0	0	1.64
21	.20	0	0	.29	.33
22	.01	0	0	0	.08
23	0	0	0	.13	0
24	0	.01	.02	0	0
25	0	0	0	0	0
26	0	0	0	.06	0
27	0	0	0	.37	1.26
28	0	0	.50	0	.21
29	0	0	.12	0	0
30	0	.17	0	0	0
31		0		0	0
Total	.50	1.16	1.34	1.92	8.73

2000270011

RAINFALL

Upper Coastal Plain Research Station

Rocky Mount, NC 1986

Date	April	May	June	July	August
1	0	0	0	1.02	0
2	0	0	0	.57	0
3	0	0	0	.05	1.35
4	0	0	0	0	.21
5	0	0	0	0	0
6	.02	0	0	0	0
7	.35	0	0	0	1.54
8	.17	0	.62	0	0
9	0	0	0	0	0
10	0	0	0	0	0
11	0	0	0	.93	0
12	0	0	0	.30	2.40
13	0	0	0	0	1.35
14	0	.21	0	0	0
15	0	.15	.10	0	0
16	0	0	.35	0	.26
17	.09	0	0	0	.53
18	.19	0	.47	0	0
19	0	.35	0	0	1.80
20	0	1.24	0	0	1.02
21	.35	.36	0	0	.13
22	0	.52	0	.11	.11
23	0	0	0	.02	0
24	0	.05	0	.20	0
25	0	0	0	.12	0
26	0	0	0	0	0
27	0	0	0	0	0
28	0	0	.65	0	2.49
29	0	.24	.20	0	0
30	0	.02	.06	.04	0
31		0		0	0
Total	1.17	3.14	2.45	3.36	13.19

...ust
0
0
1.35
.21
0
0
1.54
0
0
0
0
2.40
1.35
0
0
.26
.53
0
1.80
1.02
.13
.11
0
0
0
0
0
2.49
0
0
0
13.19

RAINFALL

Lower Coastal Plain Tobacco Research Station

Kinston, NC 1986

Date	April	May	June	July	August
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	.13	1.00	.92
4	0	0	0	0	.41
5	0	0	0	0	.03
6	0	0	0	0	0
7	.61	0	.28	0	0
8	0	0	0	0	0
9	0	0	.49	0	.28
10	0	0	0	.16	.31
11	0	0	0	.47	.46
12	0	0	0	.20	.40
13	0	0	0	0	.30
14	0	.16	1.68	0	0
15	0	.33	.57	0	.04
16	.10	0	1.01	0	0
17	.10	0	1.40	.10	.49
18	.15	0	1.58	.01	0
19	0	.04	0	.57	1.48
20	0	.70	.17	0	.42
21	.47	.44	0	0	.02
22	.11	.20	0	.08	0
23	0	0	0	0	0
24	0	0	0	.06	0
25	0	0	.19	.56	0
26	0	.21	0	.08	0
27	0	0	0	0	0
28	0	.01	.22	.04	.62
29	0	0	.73	.24	0
30	0	0	.50	0	0
31		0		0	0
Total	1.54	2.09	8.95	3.57	6.18

2000270013

RAINFALL

WAYNESVILLE, N.C.

Date	May	June	July	August	Sept.
1			.03		.23
2		.01	.34	.02	.25
3			.11	.02	.30
4					.71
5				T	T
6				.10	
7	.01	1.04			
8	T	.50	.21	T	
9		.51		T	
10		T	.34	.02	
11		.15	.05	.52	
12	.81		.03	.01	.26
13	.77				
14	.14		.07	.01	
15			.10		
16	T				.09
17	.43			1.01	
18	T			1.12	
19	.21				T
20	.18			1.06	.05
21					.08
22			T		
23			T	.10	
24	.42		1.27	.06	
25			.03		
26	.25		.06		
27	.01		.08	.77	
28	.69		.04	.04	
29	.13				
30	.17	T	T	T	.12
31	.02			.01	T
Total	4.47	1.71	3.05	5.08	2.09

Title: NC 03905 Limited Growth of Metabolic Sinks to Enhance Quality of Flue-cured Tobacco

Project Leaders: H. Seltmann (USDA, ARS)

I. Summary of Research:

A. Preliminary regional tobacco growth regulator test.

The regional committee elected to study the use of the experimental SDS-36991 as a tankmix with the registered agents of maleic hydrazide (MH), Prime , and Bud Nip. SDS-36991 was used as the first phase instead of the fatty alcohols (FA) in the sequential applications of the tank-mixes (see Table 1). Sucker control was more effective when there were three phases instead of two in the sequential applications. (Compare #4 with #3.) A three-phase sequential using FA or SDS-36991 was more effective than the same amount of these chemicals when one part (phase) was used in the tankmix with the MH in a two-phase sequential application. (Compare #4 with #6; #5 with #7.)

B. Advanced regional tobacco growth regulator test.

The selected treatments for the advanced test were those that passed the 1985 preliminary test (see Table 2). As in the preliminary test, the three-phase sequential applications were more effective in sucker control than the two-phase sequential. (Compare #5 with #4; #8 with #10.) The 76 mg/plant rate of SDS-36991 was almost as effective as the 151 mg rate. (Compare #8 with #7.) The intermediate rate of 114 mg/plant as used in the preliminary test #5 (Table 1) may be the suggested rate for maximum control without the excessive use of this chemical.

It would appear that SDS-36991 could substitute for FA in sequential applications. There may be an advantage with SDS-36991 in that it is systemic in action when it contacts the sucker tissue whereas the FA is just contact. This systemic nature may be more effective in the control of the second sucker in the leaf axil.

The IAP-812/IAP-680 sequential application was similar to the FA/MH control treatment (Table 2). It would appear that the IAP-812, as the initial chemical in the sequential application, is not as effective as the FA. (Compare #6 with #7.) The effectiveness of IAP-680 is similar to MH. (Compare #7 with #4.)

There were no outstanding differences among the chemical treatments for the chemical and physical properties of the cured tobacco. The hand-suckered treatment tended to be different from all others.

C. Herbicide and growth regulator persistence study.

Sucker control was practiced with MH or flumetralin on tobacco plants grown in soil not treated or treated with one of the following herbicides:

Paarlan, Devrinol, Prowl, Enide, or Tillam. The growth of the wheat cover crop was determined (Table 4). In the absence of a herbicide, the use of flumetralin reduced the number, total weight, and weight per plant of the wheat plants when compared to those where MH was used for sucker control on the tobacco. In the presence of each herbicide flumetralin reduced the number and total weight of the wheat plants when compared to MH. The weight per wheat plant was also reduced except in the presence of Tillam. With respect to the number of wheat plants the greatest effect was in the presence of flumetralin with Paarlan and Prowl; the smallest effect was with Tillam. (The study is in cooperation with T. J. Sheets.)

D. Comparison of MH, FST-7, and the tankmix of MH plus fatty alcohols.

Following an initial application of fatty alcohols (FA), MH, FST-7, or a tankmix of MH plus FA were applied (1) at the x rate one week after the initial application of FA, (2) at the x/2 rate two times one week apart beginning one week after the initial application of FA, (3) at the x rate two times one week apart also beginning one week after the initial application of FA, and (4) at the 2x rate one week after the initial application of FA (Table 5). The results indicated a tendency for better control where the MH was used. The tendency for better control comes from the fact that 11% more of the systemic active ingredient was applied with the MH than with the FST-7. The split application of x/2 followed by x/2 tended to improve control over the x rate within each of the sucker control materials even though the amount of chemical applied to the plants was the same. Apparently more MH was absorbed. The 2x amounts resulted in near perfect control for the three materials.

The only difference observed in the agronomic data was a tendency in reduced yields with the 2x rate of the materials. Chemical analyses showed no effect on total alkaloids, but there was an increase in reducing sugars from the x/2 followed by x/2, x followed by x, and the 2x rates over the x rate of the three materials. These results suggest that the former three methods of application of these materials must result in greater absorption of MH in the plant tissues.

E. Effect of gibberellic acid on the mature tobacco plant.

The lower portions of the stalks of greenhouse grown plants were treated with 10^{-2}, 10^{-3}, 10^{-4}, and 10^{-5}M gibberellic acid (GA) four weeks after topping and the application of MH for sucker control. Four weeks after GA treatment no sucker growth was observed, but there was a decided increase in stalk thickness in the areas of GA application. Stalk volume and fresh weight (FW) increased when compared to the control (see Table 6). Stalks were separated into cortex, wood, and pith. When compared to the control, cortex increased in FW, but remained the same in dry weight (DW); wood increased in FW and DW; pith remained the same in FW, but decreased in DW. Using the changes in FW and DW as a basis, one can conclude that the cortical tissues became more succulent with GA treatment. On the other hand, FW of the pith remained the same, but DW decreased indicating that there was a loss of storage materials.

Our results indicate that GA should be studied further on field grown plants to determine whether there is some practical use of this growth regulator in tobacco production.

IV. Publications:

Weeks, W. W., and H. Seltmann. Effect of sucker growth on the volatile compounds in flue-cured tobacco. Jour. Ag. and Food Chem. 34:899-904. 1986.

Seltmann, H. Effect of gibberellic acid on stalk growth of maleic hydrazide-treated flue-cured tobacco plants. Proc. Plant Growth Reg. Soc. Amer. 13:162-164. 1986.

Meyer, S. A., T. J. Sheets, and H. Seltmann. Maleic hydrazide residues in tobacco and their toxicological implications. Reviews of Environmental Contamination and Toxicology, Vol. 90. pp 43-60. Springer-Verlag, NY. 1987.

IX. Acknowledgments:

Joseph A. Priest for excellent technical assistance.

Table 1. 1986 Preliminary Regional Sucker Control Test: Flue-cured*

Treatment	Sucker control (%)	Yield (lb/a)	Price index ($/cwt)	Acre index ($/a)	Quality** index	Degree of injury	Total alkaloids (%)	Reducing sugars (%)
1. TNS	0	1282	141	1808	46	--	2.38	13.9
2. HS	44	1739	147	2556	42	--	3.12	14.9
3. FA/MH 4%/170mg	67	2081	157	3267	50	0	2.81	16.7
4. FA/FA/MH 4%/4%/170mg	91	2349	158	3711	46	0	3.03	16.5
5. SDS-36991/SDS-36991/MH 114mg/114mg/170mg	97	2277	156	3583	42	0	2.88	17.8
6. FA/(FA + MH) 4%/(4% + 170mg)	84	2454	158	3877	45	0	2.72	19.4
7. SDS-36991/(SDS-36991 + MH) 114mg/(114mg + 170mg	86	2302	155	3568	48	0	2.92	18.0
8. SDS-36991/(SDS-36991 + MH) 151mg/(151mg + 170mg)	93	2293	159	3646	47	0	2.97	18.9
9. SDS-36991/(SDS-36991 + Prime+) 114mg/(114mg + 46mg)	89	2291	158	3620	48	0	2.95	16.2
10. SDS-36991/(SDS-36991 + Prime+) 114mg/(114mg + 23mg)	91	2274	149	3388	40	0	3.09	16.4
11. SDS-36991/(SDS-36991 + Bud Nip) 114mg/(114mg + 38mg)	83	2295	154	3534	40	0	2.86	17.7

* Mean of Kinston and Oxford, N.C. - 2 reps per location.
**Quality index (Wernsman-Price) is a 1-99 rating based on government grade. High ratings are best.

Tab

Treatment
1. TNS
2. HS (also 3)
3. FA/MH 4%/170mg
4. FA/FA/MH 4%/4%/170mg
5. IAP-812/IAP- 4%/170mg
6. FA/IAP-680 4%/170mg
7. SDS-36991/SD 151mg/151mg/
8. SDS-36991/SD 76mg/76mg/17
9. SDS-36991/MH 151mg/170mg
*Mean of Kinsto
**Quality index grade. High r

Table 2. Advanced Regional Sucker Control Test: Flue-cured*

Treatment	Sucker control (%)	Yield (lb/a)	Price index ($/cwt)	Acre index ($/a)	Quality** index	Degree of injury
1. TNS	0	1193	145	1730	48	—
2. HS (also 3)	43	1761	157	2765	49	--
3. FA/MH 4%/170mg	81	2217	159	3525	47	0
4. FA/FA/MH 4%/4%/170mg	97	2357	158	3724	47	0
5. IAP-812/IAP-680 4%/170mg	78	2239	159	3560	48	0
6. FA/IAP-680 4%/170mg	86	2216	161	3568	52	0
7. SDS-36991/SDS-36991/MH 151mg/151mg/170mg	96	2241	157	3518	47	0
8. SDS-36991/SDS-36991/MH 76mg/76mg/170mg	93	2284	160	3654	48	0
9. SDS-36991/MH 151mg/170mg	78	2183	161	3515	50	0

*Mean of Kinston and Oxford, N.C. - 4 reps per location.

**Quality index (Wernsman-Price) is a 1-99 rating based on government grade. High ratings are best.

Table 3. 1986 Advanced Regional Sucker Control Test: Flue-cured

Treatment	Moisture (%)	Total* alkaloids (%)	Reducing* sugars (%)	TVB-nicotine (%)	Total* ash (%)	Filling value (ml/100gm)	Equilibrium moisture (%)
1. HS (also 3)	5.6	3.60	15.8	.097	10.62	413	11.3
2. FA/MH 4%/170mg	5.4	3.40	19.4	.150	9.36	357	11.4
3. FA/FA/MH 4%/4%/170mg	5.5	3.45	19.6	.155	9.38	411	11.8
4. IAP-812/IAP-680 4%/170mg	5.3	3.25	19.7	.146	9.65	383	11.8
5. FA/IAP-680 4%/170mg	5.2	3.31	20.5	.154	9.13	438	11.1
6. SDS-36991/SDS-36991/MH 151mg/151mg/170mg	5.6	3.65	17.8	.185	10.05	448	12.4
7. SDS-36991/SDS-36991/MH 76mg/76mg/170mg	5.5	3.58	19.2	.160	9.73	401	11.8
8. SDS-36991/MH 151mg/170mg	5.5	3.44	19.1	.159	9.85	404	11.9

*Moisture free basis.

Table 4. Effect on a wheat cover crop following tobacco from the use of MH or flumetralin for sucker control in the absence or presence of different herbicides.

Herbicide	Growth reg.	No.	Wheat* wt.(gm)	Wt./plant(gm)
---	MH	73.0	118.7	1.63
Paarlan	MH	63.3	74.0	1.17
Devrinol	MH	74.3	88.3	1.18
Prowl	MH	74.7	111.7	1.53
Enide	MH	77.3	122.3	1.74
Tillam	MH	81.0	86.7	1.08
---	Flumetralin	66.0	69.7	1.13
Paarlan	Flumetralin	48.0	57.7	1.16
Devrinol	Flumetralin	66.3	67.3	1.03
Prowl	Flumetralin	59.0	64.7	1.09
Enide	Flumetralin	65.6	65.3	1.00
Tillam	Flumetralin	68.7	75.3	1.12

*Mean of 3 reps; 5 subsamples per rep; Whiteville, 1986.

Table 5. Percent sucker control using different methods of application of MH, FST-7, or a MH:fatty-alcohol tankmix after an initial application of FA.

Method	MH	FST-7	(MH + FA)
FA/x	84.6 de	82.4 e	93.2 bc
FA/$\frac{x}{2}$/$\frac{x}{2}$	91.1 c	85.7 d	94.6 b
FA/x/x	99.6 a	99.4 a	99.7 a
FA/2x	99.2 a	99.5 a	99.9 a

Means with the same letter are not significantly different at the 0.05 level.

Table 6. Effect of gibberellic acid on stalk growth of tobacco plants following decapitation and treatment with maleic hydrazide.*

Property		Control	Gibberellic acid				
			10^{-5}M	10^{-4}M	10^{-3}M	10^{-2}M	c.v.(%)
Stalk volume	(ml)	84 d	98 cd	118 c	169 b	204 a	15
Stalk fresh wt.	(gm)	88 d	104 cd	120 c	170 b	203 a	17
Stalk length	(cm)	29 a	27 b	29 a	28 ab	29 a	3
Cortex fresh wt.	(gm)	26 c	30 c	35 b	38 ab	41 a	11
Wood fresh wt.	(gm)	27 d	43 cd	53 c	107 b	133 a	23
Pith fresh wt.	(gm)	32 a	29 ab	30 ab	23 b	27 ab	16
Cortex dry wt.	(gm)	4.8 a	4.4 a	5.3 a	4.4 a	4.6 a	14
Wood dry wt.	(gm)	9 d	13 cd	15 c	20 b	25 a	20
Pith dry wt.	(gm)	4.4 a	3.4 b	3.5 b	2.0 c	1.8 c	15

*Means followed by the same letter are not significantly different at the 10% level of probability.

Title: NC03996 - Nicotiana Leaf Surface Chemistry

Project Leader: David A. Danehower

I. <u>Summary of Research</u>

The objectives of this project are:

A) to conduct studies on the effects of cultural and curing practices on tobacco leaf chemistry and quality.

B) to provide support for the analysis of leaf surface constituents in plant breeding programs aimed at the development of new tobacco types or cultivars with enhanced flavor and aroma or pest resistance.

C) to develop preparative and analytical procedures for tobacco leaf surface constituents and provide materials for biological testing.

Specific experiments designed to meet the objectives include the following:

1. Isolation and Biological Testing of <u>Nicotiana</u> Leaf Surface Compounds (with Dr. Donn Shilling and Dr. Mary Menetrez)

Preparative isolations of <u>Nicotiana</u> leaf surface components have progressed rapidly in the past year. Crude leaf surface extracts, obtained from bud leaves and suckers of a number of <u>N. tabacum</u> types have been fractionated using several different chromatographic procedures.

Initial fractionations are carried out using Sephadex LH-20 in order to obtain compounds grouped by chemical class (hydrocarbons, wax esters, nonpolar terpenes, polar terpenes, sucrose esters, etc.). In many cases further purification has not been required.

For those fractions requiring additional fractionation, low pressure chromatography has been used with either normal (silica gel) or reversed phases (octadecyl silane or octyl silane). A variety of solvent systems have been employed, depending on the materials to be isolated or the stationary phase use. Essentially pure alpha and beta 4,8,13-Duvatriene-1,3-diols are afforded by these techniques.

A final semi-preparative isolation is required for other compounds (<u>Z</u>-abienol, individual sucrose ester groups, etc.). High performance columns are being used for this final step. Stationary phases include those mentioned earlier as well as a bonded amine phase.

Biological testing of these fractions and pure compounds has included examinations of both allelopathic (with Dr. Donn Shilling, U. of Fla.) and plant pathological testing (with Dr. Mary Menetrez and Dr. Harvey Spurr). These tests are in preliminary stages.

Allelopathic testing of Sephadex LH-20 fractions at various concentrations has yielded some interesting preliminary data (Table 1). Fractions 69 and "wash", which contain the duvatriene diols and sucrose esters respectively, show inhibition of root and shoot growth at higher concentrations, whereas lower concentrations stimulate growth of the two test species. The crude leaf surface wash also follows this pattern. Previous reports of plant growth activity of these two groups of compounds has indicated growth inhibition effects, but this would appear to be the first report of growth stimulatory effects. Further work is currently underway to test pure duvane and sucrose ester isolates.

2. Development of a Thin Layer Densitometry Procedure for Rapid Screening of Tobacco Leaf Surface Chemistry

A central thrust of our research efforts in leaf surface chemistry has been the development of rapid analytical methods for the analysis of tobacco leaf surface components. To date, methods development has focused on the analysis of individual components such as the sucrose esters and Z-abienol. Our most recent efforts have involved the development of a simple and relatively inexpensive technique for the quantitation of all the major leaf surface component classes, thin layer densitometry.

In brief, the procedure involves the spotting of known amounts of crude leaf surface extracts onto high performance thin layer chromatographic plates (silica gel G) and development with a hexane : chloroform : isopropanol (80:10:10) or similar solvent composition. This procedure allows the clear resolution of hydrocarbons, Z-abienol, alpha-and beta-duvatrienediols, alpha- and beta-duvatrienemonols, and sucrose esters. In addition, several other unidentified components are resolved as well. Charring of this chromatogram with a Chromic-Sulfuric Acid mixture yields carbonized spots which are readily quantitated using a scanning densitometer. The cogent features of this method are: 1) Virtually no sample preparation is involved, 2) up to twenty samples can be developed in a single run 3) compounds are generally separated by compound class, rather than individual components within a class.

3. Mapping of Flue-Cured Tobacco Inorganic Constituents During Curing Using Neutron Activation Analysis (NAA) (with Dr. Jack Brenizer and Dr. Bob Jenkins)

The use of instrumental neutron activation analysis (INAA) in the determination of selected element in biological tissues has been reported by numerous authors. This work is the first to apply NAA techniques to the within-leaf and within-plant distribution of selected inorganics in tobacco.

Three replicate plots of McNair 944 were grown under standard cultural conditions and sampled at three stalk positions at harvest. In addition samples were taken at several positions within the lamina and midrib of leaves from each stalk position. Similarly, samples were taken during and after curing in order to determine whether inorganic elements are transported within the leaf during curing.

Table 1 .

Fraction
24
"
"
34
"
39
"
44
"
49
"
"
64
"
"
69
"
"
"
98
"
109
"
113
"
"
wash
"
"
"
crude
"
"
"
"
"

[1]Average

[2]White s

[3]No root bleachi

[4]Strong

[a]Total f

[b]Percent

Table 1. Effects of N. tabacum leaf surface extracts on growth of two weed species.[1]

% Inhibition					
		Barnyardgrass		Hemp sesbania	
Fraction	Conc. (ppm)	TFW	PSRFW	TFW	PSRFW
24	100	+9.0	+18.7	3.4	4.7
"	10	9.6	13.2	2.2	3.0
"	1	-	-	4.9	7.6
34	100	+8.9	+18.5	7.4	3.2
"	10	6.7	9.4	6.7	9.9
39	100	12.8	18.2	8.4	13.2
"	10	23.1	34.0	1.1	1.2
44	100	4.2	2.8	6.8	10.6
"	10	0	0	+5.1	+8.6
49	100	21.6	35.0	11.7	17.6
"	10	30.8	45.3	+5.5	+9.6
"	1	-	-	8.0	12.3
64	100	38.1	61.2	11.2	17.2
"	10	2.6	7.8	11.2	17.3
"	1	+28.9[2]	+53.1[2]	-	-
69	100	43.6[2]	69.0[2]	23.2[4]	36.4[4]
"	10	38.6[2]	59.2[2]	13.5	21.0
"	1	+15.7	+29.1	-	-
"	0.1	+55.5	+101.4	-	-
98	100	19.9	32.8	17.6	27.0
"	10	7.7	11.3	+9.0	+14.8
109	100	26.8	43.3	18.1	28.3
"	10	+9.8	+17.4	8.2	9.3
113	100	+10.2	+18.5	18.2	27.6
"	10	+14.4	+24.9	+6.3	+10.4
"	1	-	-	3.5	5.4
wash	100	36.2[2]	57.1[2]	14.1	22.1
"	10	15.9	19.2	8.3	13.1
"	1	+32.3	+58.9	28.3	43.6
"	0.1	+56.7	+103.8	+2.1	+3.2
crude	1000	58.7[3]	84.9[3]	27.5	43.2
"	100	43.4	68.1	19.5	30.2
"	10	0.4	0.7	13.7	21.1
"	1	+14.7	+27.1	7.6	11.8
"	0.1	+34.6	+63.4	0.8	1.2
"	0.01	+42.1	+77.0	-	-

[1]Average of 3 replications and 2 experiments.

[2]White shoots and very little root growth.

[3]No root growth, very little shoot growth (i.e., not enough to look for bleaching.

[4]Strong root inhibition, abnormal root development.

[a]Total fresh weight.

[b]Percent shoot to root fresh weight.

Results of this experiment indicate that chlorine, potassium, sodium, magnesium, and calcium have definite concentration trends within the leaf. Calcium concentration is approximately 1.7 times higher at the base of the leaf than at the tip for both lamina and midrib. No trend was observed between calcium levels in going from the lamina adjacent to the midrib to the leaf margins.

Magnesium displays a similar trend with appoximately twice the concentration in basal lamina compared with the tips (approximately 1.7 times great for the midrib analyses). Again, no trends were evident in moving from the interior lamina to the margins.

Manganese appeared to be evenly distributed within the lamina and midribs. Higher overall concentrations were observed in the lamina tissue compared with the midrib.

Sodium and potassium both showed a tendency to increase in concentration in the central portion of the leaf in both lamina and midrib tissue. No trend was evident in going from inner lamina to outer lamina for either element.

Chlorine and bromine decreased tremendously in concentration in both lamina and midrib in going from the base to the tip of the leaf. Again, no significant differences were observed in interior versus marginal lamina.

The collection of additional data continues at this time for other stalk positions, points during curing, and elements. Inorganics in tobacco play a key role in burn characteristics of the cured leaf. These experiments should provide information of use to the tobacco industry on the potential for altering elemental composition by the use of various leaf portions in the blending of tobacco.

II. a) Graduate Students: Me. David Lawson, M.S. candidate. Thesis topic: Chromatographic Isolation and Analyses of *Nicotiana* Leaf Surface Components.

b) Special Students: Mr. John Weeks, R. J. Reynolds Undergraduate Apprentice. Research Area: Preparative Isolations of *Nicotiana* Leaf Surface Compounds.

IV. Publications:

Shilling, D., D. Worsham, and D. A. Danehower. 1986. The effect of mulch, tillage, and herbicides on weed control, yield, and quality of flue-cured tobacco. Weed Science 34:738-44.

Jenkins, R. W., H. J. Grubbs, R. T. Bass, J.S. Brenizer, D. C. Jones, D. A. Danehower, and R. C. Long. 1986. The determination of selected inorganic elements in tobacco by N.A.A. Modern Trends in Activation Analysis. Copenhagen, Denmark, June 23-27, 1986. p. 877-886.

V. Manuscripts Accepted for Publcation:

Danehower, D. A. A rapid method for the isolation and analysis of the sucrose esters of tobacco. Tobacco Science.

Danehower, D. A., R. Isac, H. Grubbs, M. T. Core, and S. B. Hassam. A rapid method for the analysis of Z-abienol. Tobacco Science.

Jenkins, R. W., H. J. Grubbs, R. H. Newman, R. T. Bass, J. S. Brenizer, D. C. Jones, T. G. Wiliamson, D. A. Danehower, and R. C. Long. The distribution of selected inorganic elements in tobacco by Instrumental Neutron Activation. J. Radioanal. Nucl. Chem.

VII. Papers Presented at Professional Meetings:

Danehower, D. A. A rapid method for the isolation and analysis of the sucrose esters. Tobacco Chemists' Research Conference. Knoxville, TN. October 13-16, 1986. Abstracts, p. 24.

Jenkins, R. W., H. J. Grubbs, R. H. Newman, R. T. Bass, J. S. Brenizer, D. C. Jones, T. G. Williamson, D. A. Danehower, and R. C. Long. Distribution of selected inorganic elements within the bright tobacco leaf. Tobacco Chemists' Conference. Knoxville, TN. October 13-16, 1986. Abstracts, p. 18.

Schell, L. P., D. A. Danehower, J. R. Anderson, and R. P. Patterson. Application of HPLC techniques to the analysis of nucleotides in predicting cold tolerance of maize hybrids, North Carolina A.C.S. Meeting. Chapel Hill, N.C. April 19, 1987. Abstracts, p. 3.

Lawson, D. R. and D. A. Danehower. Preparative and analytical chromatography of Nicotiana leaf surface lipids. Southeastern Regional A.C.S. Meeting. Louisville, KY. Nov. 3-5, 1986. Abstracts, p. 88.

IX. Acknowledgement:

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Title: NC03837 - Chemical Evaluation of Volatile Compounds from Tobaccos that are Genetically Controlled for Alkaloids

Project Leader: W. W. Weeks

Tobacco Flavor Enrichment Using Varietal Screening for Volatile Compounds

Cigarettes are made from a blend of tobacco types to obtain specific flavor and taste characteristic when the different types, flue-cured, burley, Maryland and Oriental tobaccos are combined. Physical differences between these types also compliment each other and the blends are more conducive to smoking than individual types. Chemical differences between tobacco types are more quantitative than qualitative; therefore, different tobacco types are blended to amplify certain notes during smoking.

Genetic differences in flue-cured tobaccos also produce quantitative differences in chemistry and chemical differences correlate with physical differences in cultivars. In 1984 and 1985, our laboratory studied the volatile chemistry, alkaloids, and reducing sugars of 8 old and 8 currently popular grown flue-cured varieties. Tobacco from these studies was made into cigarettes for panel evaluations by expert panelists for flue-cured character and smoke strength. Cigarettes from each cultivar were compared to cigarettes from NC-2326 used as the check variety because of its status established by the minimum standards committee regulating genetic material for varietal release. Panel rankings equal to and higher than the check were considered of better smoking quality than those substrates with lower ranking than NC-2326. Upstalk tobacco of B grade, or smoking leaf only was used to make cigarettes. Following panelist scrutiny of each variety for flue-cured character and smoke strength, volatile profiles of neutral volatiles, obtained by steam distillation, were determined by capillary gas chromatography. Statistical analyses of the chemical data and correlations between chemical and panelist data suggested flue-cured character was associated with volatiles and smoke strength with alkaloids and total volatile bases.

This phenomenon was encouraging because the genetics of alkaloids are understood and the association of smoke character and volatiles suggested selection and breeding could be use to increase volatiles or flue-cured character and improve the quality of tobacco. Further effort was made to relate directly with specific volatile compounds that impose impact upon smoke flavor and aroma.

Separation of essential oils from Sp.G-70, a variety with high levels of aromatic properties, by preparatory G.C. and structural determinations by G.C. mass spectometry showed that 13 of the volatile compounds composed 80% of the total concentration of the neutral volatiles that are related to aroma of flue-cured tobacco. This does not necessarily indicate that 80% of the total flavor and flue-cured character depends on these 13 compounds only, but the impact of these compounds upon smoking is well documented. The relative concentration of these 13 compounds with respect to compounds of negligible concentrations certainly accentuates the importance of them because of their magnitude. Further observations indicate varieties containing the highest levels of these compounds ranked higher by panelist and the tobacco also had

more aroma.

To determine if the smoking quality of flue-cured tobacco could be improved by increasing volatiles, a solution containing volatiles obtained from Sp. G-70 was added quantitatively to DB-101 a tobacco low in volatiles. In the smoking test, DB-101 had ranked below the check and Sp. G-70 above the check, and the choice of adding the highest to the lowest appeared the best selection to experiment with. The enriched DB-101 tobacco was made into cigarttes. Panelist compared the enriched cigarettes with regular DB-101 and Sp. G-70 cigarettes. Smokers described the enriched tobacco better than either of the two tobaccos composing the blend. The enriched tobacco was very characteristic of an all bright cigarette rather than a blend. The addition of a second solution to the enriched DB-101 tobacco obtained from the acidic fraction of Sp. G-70 was added comparable to the procedure used in the first test. Cigarettes containing both additives were made and smoked for subjective evaluations. The cigarettes, with both solutions added, smoked similar to a blended cigarette and an oriental note was described. Addition of tobacco solutions from different chemical fractions suggested that blending of solutes to a homogenous tobacco sample could be substituted for tobacco. This, however, is not a practical process for manufacturing cigarettes, but it is suggestive that the smoking quality of tobacco can be improved by increasing specific compounds in a cultivar.

During 1986, DB-101, Sp. G-70, and NC-2326 were grown at Reidsville, North Carolina, to make cigarettes and for the purpose of blending tobacco for subjective and chemical analyses. B grade tobaccos only were used and each variety was cleaned up by removing damaged leaves and foreign material and stems were removed by machine. The quality of all the tobaccos was greatly improved from the cleanup. Cigarettes were made from each DB-101, Sp. G-70, and NC-2326, and blends of each by equal weights DB-101 x NC-2326, DB-101 x Sp. G-70, Sp. G-70 x NC-2326 and DB-101 x NC-2326 x Sp. G-70. Cigarettes from NC-2326 were used as a standard by panelist as in the previous studies. Smoking data from panelist were inconclusive, personal preference were indicated; however, varietal interactions and compliments from blending the varieties were described. Blends of (DB-101 x Sp. G-70) were prefered to (Sp. G-70 x NC-2326) and (NC-2326 x DB-101). Blending of all three varieties was least preferred, but the characteristic impact of Sp. G-70 was described as being the prevalent note. DB-101 received higher rankings from panelist from the cigarettes in this crop to previous years, and this was probably due to the selectivity during processing for only good quality leaves. Sp. G-70 received lower ranking than in previous years, but the tobacco showed the presence of green tobacco having been harvested from some of the plots.

Blending of the tobacco improved smoking quality, reduced burn time and decreased tar delivery and cigarettes from varietal blends compared favorably to blends with different tobacco types. This experiment will be repeated again in 1987.

The objective of this research is to determine positively that certain volatile compounds contribute to tobacco quality and that by breeding and selection these compounds can be increased. A second objective is to select for flue-cured varieties that can substitute for oriental tobacco and give

oriental note to a blend

Major Volatiles Contributing to Flue-Cured
Character from Sp. G-70 and DB-101 Tobaccos

Compound	Sp. G-70 PPM	DB-101 PPM
Solanone	51.00	37.00
Damescenone	33.00	23.00
Megastigmatrienone	33.00	14.00
Megastigmatrienone(isomer)	22.00	10.00
Oxysulanone	24.00	35.00
Dihydroactinolide	28.00	11.00
Farnesylaretone	63.00	30.00
4-Hydroxy-β-damascone	63.00	76.00
4-Keto-β-damascone	48.00	23.00
Tetrahydroactinolide	39.00	16.00
4-Hydroxy-α-ional	46.00	29.00
3-4-Dehydro-1,5,6,trimethyl ethyl napthalene	57.00	30.00
5-Hydroxy-6,7-dimethyl benzofuran	150.00	100.00

Smoke is a product of combustion consisting of over 3000 components. The flavor of each puff is free of the previous one and does not accumulate. It is, however, necessary to have pleasant attributes and satisfying notes in each puff. Compounds in tobacco that accentuates aroma and transfer into the smoke unchanged are like icing on a cake. Such compounds have been identified from tobacco but the concentration of such compounds have always been considered too low, therefore, neglected by all but flavorist. The difficulty associated with analytical analyses of these compounds and the concern for their labile properties have produced very poor results lower than existed. A new method initiated in our laboratory and a different philosophy, that such compounds are not so sensitive to extraction, has resulted in higher quantities of flavor compounds that have aroused new interest because of the increased concentration.

Extraction of organic constituents as a solute from the tobacco and

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removable of interfering compounds proceeding 24 hour distillation of the solutes has increased the concentration of known flavor compunds responsible for flue-cured character in smoke. The significant differences in the concentration, found by this technique, has encouraged emphasizing the importance of these major compounds rather than trying to relate to all of the many compounds and the interactions and mechanisms involved with them. Increasing the levels of these major flavor compounds, results in significant differences in smoking characteristics as designated by the comparison of Sp. G-70 and DB-101 smoke evaluations.

Title: NC05149 - Analytical Methodologies Required for Chemical Analyses to Experimental Tobacco

Project Leader: W. W. Weeks

The tobacco analytical service laboratory is completing the season with only 2000 samples of low priority samples to finish. The thrust as usual for analyses has been basically reducing sugars and total alkaloids. Analyses for some project leaders include other accommodations such as nicotine and nornicotine, starch and total halogens. More than 600 samples have been screened for nicotine conversion by thin layer chromatography. The laboratory will be instigating a new program beginning next fall, because of the danger of toxicity of chloroform an alternate procedure will be used to monitor nicotine conversions for the breeding programs and variety testing program.

The laboratory has purchased new equipment, and developed software for determining total alkaloids and reducing sugars. This new system allows us to retrieve the data from each day's analyses in house as desired. This has increased the efficiency of the laboratory and has made priorities easier to meet. The goals for the future for project leaders who desire and are willing to purchase the disk, the laboratory will be able to give the data on a floppy disk as well as a hard copy. We think this will be a time saver for all. Further efforts to accommodate the needs of the N. C. State tobacco programs chemical needs are in progress.

Publications and Papers Presented:

Effects of Sucker Control on the Volatile Compounds in Tobacco. Willard W. Weeks and Heinz Seltmann. Journal of Agriculture and Food Chemistry 1986. 34:899-904.

Carotenoids a Source of Flavor and Aroma. Willard W. Weeks. Biogeneration of Aroma. American Chemical Society Publication. Chapter 12:157-166.

Paper Presented:

Tobacco Chemist Research Conference, Knoxville, TN. Oct. 1986. Chemical and Subjective Evaluations of Old and New Flue-Cured Varieties. W. W. Weeks, J. F. Chaplin, and Ray Campbell.

Title: Burley Tobacco On-Farm Tests

Project Leaders: R. L. Davis, D. S. Whitley, D. J. Bolden

I. Summary of Research:

This project has the following objectives:

A. To evaluate the performance of available burley varieties and hybrids under the varying conditions that occur in the mountains of western North Carolina.

B. To test rates, timing, tank mixes, sequential applications, and combinations of all labeled sucker control chemicals on burley tobacco.

C. To evaluate the effects of supplemental heat in curing burley tobacco.

D. Summary of results obtained with no-till burley production and results obtained with burley herbicides are given in the Weed Science section of the report.

Burley Tobacco On-Farm Test Results 1986

Drought conditions persisted through most of the 1986 season. The season began with a deficit of 10-15 inches below normal from the 1985 season. With the exception of isolated showers, dry weather persisted until late summer. Plant shortages were acute over most of the area. Transplanting was late with some growers being unable to set all of their planned acreage.

Late summer rains resulted in nearly normal yields for most of the counties. Curing conditions were generally good with the result that the best colored crop in recent years was placed on the sales floor. The season average price for the state was $155.92 which was slightly lower than the 1985 crop. The amount of the 1986 crop going into burley stabilization however, was much less than that from the 1985 crop. All prices are based on 1986 advance or support price.

Burley On-Farm Variety Tests

Although tobacco growth was not uniform, average yields for the variety tests were very good, considering the severity of the drought. The area had no general rains for most of the growing season.

Differences in yield among the varieties and hybrids tested were not as great as is sometimes observed in other seasons when growing

conditions are more favorable. Kentucky 14 and Virginia 509 are considered as standard or "check" varieties over the eight state burley belt. Yields for the two were similar this year which is not unusual. However, over a period of years, Kentucky 14 generally ranks as a high yielding variety while Virginia 509 ranks as moderate to high. Others considered as high yielders are Burley 21 x Kentucky 10, R7-11, Tennessee 86, and Burley 21 x Kentucky 14. Clays 501 and 102 have potential for high yields but are sensitive to leaf spot complexes. Infection was severe enough at some locations to reduce yield in this year's tests. Kentucky 14 x L8, a moderate to high yielding hybrid, is also sensitive to leaf spots. Kentucky 17 usually produces moderate yields in the mountain area.

Price per cwt. is generally similar for all the currently available varieties and hybrids when averaged over a period of years. Minor variations that may appear in data for one year can be attributed more to random differences within a curing barn than to actual varietal differences. The upper tiers usually cure better tobacco. Houseburn is always worse on the lower tiers and on the side of the barn away from the prevailing wind. Plots are randomized in the field and are hung in the barn as they come off the wagon in a completely random order.

Acre yields, value per hundredweight, and dollar value per acre are given in the following table.

Varieties 1986 - Summary of 7 Tests

Variety	Acre Yield	$/Cwt	$/Acre
1. Ky 14	2764	155.14	4291
2. Va 509	2761	153.91	4266
3. 21 x 10	2859	155.01	4436
4. R7-11	2881	154.92	4474
5. C501	2575	153.95	3969
6. C102	2484	152.90	3809
7. 14 x L8	2705	154.27	4178
8. Tn 86	2859	155.56	4448
9. 21 x 14	2812	154.72	4359
10. Ky 17	2588	152.82	3965

Sucker Control 1986

Tobacco was severely drought stressed over the area and growth was uneven at some locations. Rains came very late in the season resulting in an unusual spurt in tobacco growth. Overall, yields were respectable but tests were still uneven. Sucker growth was light at locations where growers harvested early, but was very heavy where tobacco was left in the field for a longer period. The area experienced a late fall with no damaging early frosts. Generally, tobacco quality was good.

Several companies again provided sucker control chemicals for in the on-farm testing program. All of the various forms, different rates, different concentrations, and tank mixes could not be fitted into our standard size field test. Consequently, three sets of chemicals were used and labeled as Codes 1, 2, or 3. Also, a special test was conducted for Uniroyal. The various treatments and results are given in the accompanying tables.

For treatments that received a contact chemical (OST, Fair 85, or Sucker Plucker), application was made when the plant was in the button stage and before topping. A second application consisting of maleic hydrazide (MH), FST-7, or another application of contact was made about a week later after plants were topped. All other chemicals including MH, Prime +, FST-7, and the tank mixes, were applied after topping. Any suckers present at topping were removed at that time and discarded and are not accounted for in the data.

The closest approach to total sucker control using currently available chemicals involves the use of sequential treatments. This method requires the application of a contact chemical at the button stage before suckers begin to grow followed by an application of a systemic (MH or FST-7) after topping about a week or ten days later. This technique controls pre-topping suckers and post-topping control will last up to six weeks after the systemic is applied.

Prime + is applied after topping down to a 6-8 inch leaf. It will give season-long control. It is a contact-local systemic which means that each sucker must be wet by the chemical or skips will occur. These few skips grow rapidly and should be removed by hand. Techniques for total coverage to prevent skips have not yet been worked out but hand equipment seems to give better coverage than power equipment. Control of 95% or better is not unusual (see tables). Some carryover problems with Prime + have been observed. Certain crops following Prime + treated tobacco have been stunted. Read the label and observe precautions noted therein before using this chemical.

Growers have shown much interest in tank mixes of one-half rate of Prime + and other chemicals. The thinking is that the half rate will cause fewer residue problems. Tank mixes of full rate of contact and half rate of Prime + and half rates of both Prime + and MH (see tables) gave excellent sucker control at all locations in this year's tests.

The MH treatments (all brands) gave excellent sucker control.

SUCKER CONTROL 1986

Code 1 Averages for 3 Tests

	Treatment	% Control	Suckers no/pl	Gn. Wt. gms/pl	Acre Yield	$/Cwt	$/A
1.	TNS	--	6.5	148	2446	151.09	3730
2.	RMH-30 @ 1GPA + Prime + @ 1/2GPA Tank Mix	99	0.2	3	2566	151.02	3895
3.	Prime + @ 1GPA @ Topping (Dropline)	98	0.3	3	2637	151.18	4010
4.	Super Sucker Stuff @ 1GPA @ Topping	96	0.6	5	2715	151.31	4133
5.	Fair 85 @ 1½GPA @ Button + FST-7 @ 2GPA @ Topping	99	0.1	0.3	2684	151.18	4068
6.	Prime + @ 1GPA @ Topping (Boom)	96	0.4	5	2658	151.35	4040
7.	OST @ 1.5GPA Button + OSM @ 2GPA @ Topping	100	0	0	2530	150.66	3830
8.	FST-7 @ 3GPA @ Topping	98	0.2	3	2561	150.56	3895

SUCKER CONTROL 1986

Code 2 - Averages For 2 Tests

Treatment	% Control	Suckers no/pl	Gn. Wt. gms/pl	Acre Yield	$/Cwt	$/A
1. TNS	--	8.8	459	2595	155.28	4029
2. OSM @ 1GPA + Prime + @ 1/2GPA Tank Mix	99	0.3	3	2811	155.73	4376
3. OST @ 1 1/2GPA + Prime + @ 1/2GPA Tank Mix	98	0.3	14	2675	154.96	4146
4. Fair 2 @ 1.5GPA	99	0.4	3	2806	155.24	4357
5. Sucker Plucker @ 1.5GPA (Button) + SSS @ 1GPA at Topping	100	0	0	3264	154.93	5056
6. Prime + @ 1GPA @ Topping	95	0.4	28	2928	155.28	4544
7. OST @ 1.5GPA (Button) + RMH-30 @ 2GPA @ Topping	100	0	0	2793	155.94	4353
8. FST-7 @ 9 qts @ Topping	99	0.4	7	2806	154.67	4342

SUCKER CONTROL 1986

SUCKER CONTROL 1986

Code 3 - Averages For 2 Tests

Treatment	% Control	Suckers no/pl	Gn. Wt. gms/pl	Acre Yield	$/Cwt	$/A
1. TNS	--	5.6	805	2319	152.78	3538
2. Fair + @ 1GPA + Prime + @ 1/2GPA (Tank Mix)	99	0.3	27	2897	152.36	4408
3. OST @ 1 1/2GPA Button + OST @ 1 1/2 GPA @ Topping	68	2.1	453	2781	151.83	4219
4. RMH-30 @ 2GPA @ Topping	99	0.2	1	2704	152.51	4121
5. Fair 85 @ 1 1/2GPA Button + FST-7 @ 2GPA @ Topping	99	0.3	5	2942	152.73	4494
6. Prime + @ 1GPA @ Topping	96	0.4	46	2958	153.03	4524
7. Fair 85 @ 1 1/2GPA Button + Fair + @ 2GPA @ Topping	100	0	0	2870	151.81	4357
8. Super Sucker Stuff @ 1GPA @ Topping	99	0.8	7	2725	152.65	4152

UNIROYAL SUCKER CONTROL TEST 1986

Kent Cochran - Jackson County

Treatment	% Control	Suckers no/pl	Gn. Wt. gms/pl	Acre Yield	$/cwt	$/A
1. TNS	----	5.2	373	2357	152.65	3599
2. RMH-30 @ 1.5GPA @ Topping	98	0.6	6	2543	153.67	3909
3. Royal Slo Gro (UBI-1238) @ 1.5GPA @ Topping	99	0.2	2	2530	151.97	3847
4. Royal Slo Gro (UBI-1444) @ 1.5GPA @ Topping	99	0.2	5	2394	153.51	3674
5. RMH-30 Sol. Gran. @ 3 3/4 lb/A @ Topping	98	0.4	7	2679	153.43	4110
6. RMH-30 Sol. Gran. (UBI-1806) @ 3 3/4 lb/A @ Topping	98	0.4	6	2353	153.47	3612
7. OST @ 1.5GPA button + RMH-30 Sol. Gran. @ 3 3/4 lb/A @ Topping	99	0.3	5	2502	151.22	3785
8. OST @ 1.5GPA button + RMH-30 @ 1.5GPA @ Topping	99	0.1	1	2421	153.39	3713

Curing With Supplemental Heat 1986

The 1986 curing season was very favorable over most of western North Carolina and supplemental heat was used very little. Federal inspectors working the three markets in North Carolina stated that the color of the 1986 burley crop was the best of any observed over the past several seasons.

Supplemental heat is a curing aid used only during periods of high humidity to prevent moisture damage during the cure. It is not considered a fundamental part of curing and only a small percentage of North Carolina burley barns are equipped to use heat.

Heat is used primarily to prevent houseburn of burley tobacco. Houseburn is a partial rotting of the curing tobacco caused by several species of fungi and bacteria that are naturally present on all tobacco leaves. These organisms multiply to an appreciable extent only during periods of high humidity that lasts longer than 24 hours. Damage is worse when free moisture is present on the leaves or the tobacco is in very high case for an extended period. Humidity within the barn may reach 100% during the night but if the barn can be dried out the next day, damage will be minimal. Generally, doors and ventilators should be opened during fair weather and closed during rainy weather and at night. The barn should always be closed while heaters are in operation.

Acre yields and values obtained with and without heat at two locations in 1986 are given in the table.

Curing With Supplemental Heat 1986
2 Locations

Treatment	Acre Yield	$/Cwt	$/Acre
Heat	2975	153.94	4579
No Heat	2687	153.37	4124

IV. <u>Publications</u>:

Davis, R. L. (+ 18 authors). 1987 Burley Tobacco Information. Ag-376, Jan. 87. 80 pp.

Title: NC 03835 Explanation of Size Distribution of Farms, and

Explanation of Size and Structure in Tobacco Farming (a Tobacco Foundation project), and

The Effects of Farm Programs on Farm Size and Structure in the Tobacco and Peanut Industries (USDA Cooperative Agreement) with Steven Margolis

Project Leader: Daniel A. Sumner

I. Summary of Research:

Our work on these projects is closely intertwined.

A data set with county level structure data for North Carolina flue-cured tobacco-producing counties from the mid-1960s through the mid-1980s has been developed and analyzed. The patterns across the state and over time have been described. These data are also being used to estimate the responsiveness of marginal costs to changes in effective quota. Census of Agriculture information for all tobacco counties in the major tobacco states for 1969 through 1982 has been put into a SAS data set and is ready for analysis.

A dynamic model of farm or enterprise size and growth has been developed. The model focuses on the impact of farmer characteristics such as age, education, and experiences as determinants of size and growth differences across farms. Current modeling efforts are directed toward a more complete mathematical representation of the forces influencing farm entry, size, growth and exit. We emphasize interactions between size and growth, as well as human capital factors.

II. Graduate Students: Arthur Sparrow, Parrie Henderson

IV. Publications:

Peace, Robert L. and Daniel A. Sumner. "Income Taxes and Farm Sector Investment: The Reasoning and Some Evidence." The Journal of Agricultural Taxation and Law 7, 4 (Winter 1986): 347-356.

Sumner, Daniel A. Structural Consequences of Agricultural Commodity Programs. AEI Occasional Paper. Washington, D.C.: American Enterprise Institute, 1986.

Sumner, Daniel A. "The Competitive Position of Southern Commodities: Some Trends and Underlying Forces." Invited paper presented at the annual meeting of the Southern Agricultural Economics Association, February 1986, and published in the Southern Journal of Agricultural Economics 18 (July 1986): 49-59.

V. Manuscripts Accepted for Publication:

*James D. Leiby and Daniel A. Sumner. "An Econometric Analysis of Size and Growth Among Dairy Farms." Presented at a joint session of the

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American Agricultural Economics Association and the Econometric Society, New Orleans, December 1986, and to appear in the American Journal of Agricultural Economics, May 1987.

VII. Papers Presented at Professional Meetings:

*James D. Leiby and Daniel A. Sumner. "An Econometric Analysis of Size and Growth Among Dairy Farms." Presented at a joint session of the American Agricultural Economics Association and the Econometric Society, New Orleans, December 1986, and to appear in the American Journal of Agricultural Economics, May 1987.

Leiby, James D. and Daniel A. Sumner. "An Analysis of Differences in Farm Size and Growth: The Case of Southern Dairy Farms." Presented at the 1986 annual meetings of the American Agricultural Economics Association; abstract forthcoming in the December 1986 American Journal of Agricultural Economics.

Margolis, Steven and Daniel A. Sumner. "Tie-In Sales in Peanut Contracting: An Economic Analysis of a Marketing Puzzle." August 1986. Presented at an Agricultural Economics Workshop, Dept. of Economics and Business, N.C. State University, October 1986.

VIII. Graduate Student Theses Completed:

D. Arthur Sparrow, Master of Science in Management, "The Structure of North Carolina Flue-Cured Tobacco Enterprises."

Title: NC 13943 The Effects of Farm Programs on Prices, Quantities, and Incomes of Field Crop Producers and Consumers

Project Leaders: Randal R. Rucker and Daniel A. Sumner

I. Summary of Research:

Algebraic models of the aggregate flue-cured and burely leaf tobacco industries have been developed and used to project various prices, quantities and values under alternative scenarios. The model highlights the interaction among quota levels, disappearance, and expected inventories. Quota levels have recently been well below disappearance, so stocks have been falling rapidly. This is expected to change in the next few years as excess inventories are depleted.

The recent budget history of the tobacco program has been revealing regarding the measurement of federal outlays for agriculture. The first four years of the `no net cost program' saw large net CCC outlays for tobacco. However, the next few years will see large net inflows as stocks are sold and assessment funds are transferred to the CCC. The federal budget does not adequately reflect the offsetting value of accumulated inventories during periods of large outlays. This accounting convention can distort the understanding of policy consquences.

II. Graduate Student: Ruey-Er Chang

IV. Publications:

Sumner, Daniel A. and Julian M. Alston. Effects of the Tobacco Program: An Analysis of Deregulation. AEI Occasional Paper. Washington, D.C.: American Enterprise Institute, 1986.

V. Manuscripts Accepted for Publication:

*Sumner, Daniel A. "Budget Costs of a `No Net Cost' Tobacco Program." Presented at the 32nd Tobacco Workers Conference, Baltimore, Maryland, January 13, 1987, and forthcoming in Current Issues in Tobacco Economics, proceedings of the conference, ed. Farrell Delman.

Sumner, Daniel A. and Julian M. Alston. "Substitutability for Farm Commodities: The Demand for U.S. Tobacco in Cigarette Manufacturing." American Journal of Agricultural Economics, forthcoming 1987.

VII. Papers Presented at Professional Meetings:

*Sumner, Daniel A. "Budget Costs of a `No Net Cost' Tobacco Program." Presented at the 32nd Tobacco Workers Conference, Baltimore, Maryland, January 13, 1987, and forthcoming in Current Issues in Tobacco Economics, proceedings of the conference, ed. Farrell Delman. proceedings.

Sumner, Daniel A. "The `Budget Costs' of Commodity Programs." Presented at the 1986 annual meetings of the American Agricultural Economics Association, Reno, Nevada, July 1986, as part of an organized symposium, "The Budget Costs of Farm Commodity Programs: Issues, Measurement, Projections, and Politics."

Sumner, Daniel A. "The Budget Costs of a `No Net Cost' Tobacco Program." Presented at the 1987 annual meetings of the Southern Agricultural Economics Association, Nashville, Tennessee, February 1987.

Title: NC03942 Crop Production Decisions in a Dynamic Uncertain Environment

Project Leader: S. A. Hatchett

I. Summary of Research:

Developed an approach to estimate the effect of price changes on the variability of yield and profit. The approach derives an indirect expected utility function, and develops a set of conditions relating input demands, supply, and profit to the marginal effects of changes in price or yield distributions. This is a generalization of the cost or profit function approach that incorporates risk-averse behavior. Also developed a theoretical model to assess the value of improved uniformity in a crop stand. Better uniformity can increase the effectiveness of some operations and reduce the cost of others. Work continues on deriving efficient ways to estimate these models.

Estimated the costs and benefits of tobacco seedbed mowing technology developed by Crop Science extension personnel. Costs were for purchase, operation, and maintenance of the mower. Benefits include an approximate 25 percent reduction in seedbed size and concomitant variable seedbed costs; similar or larger savings in transplant labor; and ability to delay transplanting if field conditions warrant. Net benefits were shown significantly positive using conservative estimates of benefits.

Estimated the demand for cigarettes when sales data include substantial purchases across state lines. This has been a source of bias when estimating demand at the state level.

IIB. R. J. Reynolds Undergraduate Research Apprentice:

Charles Umberger

V. Manuscripts Accepted for Publication:

Smith, W.D., Peedin, G., Hatchett, S., Sappie, G. Clipping Tobacco Plantbeds, N.C. Ag. Extension Service. AG series. Forthcoming.

VII. Papers presented at Professional Meetings:

Hatchett, S. A. "An Analysis of Across-Border Cigarette Purchases". Presented at the 32nd Tobacco Workers' Conference. Baltimore, MD. Jan. 14, 1987.

IX. Acknowledgements:

Glenn Sappie provided able assistance preparing and modifying tobacco plantbed budgets.

Title: NC 02149 Analysis of International Trade Policies

Project Leader: P.R. Johnson

I. Summary of Research:

Quality is one of the dimensions of tobacco that is alleged to affect international trade. This study is concerned with using market data to see if any changes in quality can be inferred. Preliminary work indicates that C tobacco has behaved differently than B and X. The amount of C tobacco going under loan appears less price responsive than the other two.

II. Graduate Students:

Marianne Kowalski

Title: Biology, Ecology and Management of Insects in Tobacco: NC03983

Project Leader: Emmett P. Lampert

I. Summary of Research:

A. Evaluation of Insecticides for Control of Insect Pests

The objectives of these experiments were to evaluate candidate insecticides for 1) efficacy against various soil and foliar insect pests, 2) phytotoxic symptoms when applied alone and in mixes, and 3) effects on yield and quality of tobacco.

Experiments were conducted at the Border Belt Tobacco Research Station (BBTRS), Central Crops Research Station (CCRS) and the Upper Piedmont Research Station (UPRS) to determine the efficacy of various soil-applied, transplant water and foliar-applied insecticides against tobacco wireworms, tobacco flea beetles, green peach aphids, tobacco budworms and tobacco hornworms on flue-cured tobacco. Soil insecticide and transplant water tests were conducted at the BBTRS and the UPRS, while foliar-applied tests were conducted at BBTRS and CCRS. At the BBTRS, a 14 treatment soil insecticide test was designed to determine the efficacy of selected preplant incorporated, transplant water, and side-dress pesticides against tobacco wireworms and green peach aphids. An additional six treatment foliar-applied test was designed to evaluate the efficacy of foliar applications of Karate 1E and Orthene TIS against tobacco budworms. At the UPRS, the 14 treatment soil-applied test was repeated with minor modifications. At the CCRS, five foliar-applied insecticide tests were conducted. These tests were primarily designed to determine the efficacy of candidate insecticides against tobacco budworms and to a lesser extent tobacco hornworms. Due to the bulk of the results of these experiments, the reader is referred to "Chemical Tests in Flue-Cured Tobacco, 1986" for specific material performance.

B. Effects of Aphid Control on the Incidence of Viruses in Large-Field Plots (with G. V. Gooding, Jr.)

The objective of this project was to determine the feasibility of virus management on large-field plots through extensive aphid management and control (elimination of any appreciable aphid population buildup on the tobacco).

This research was conducted on land rented in Carteret Co. Carteret Co. was selected because of its history of high levels of potato virus Y (PVY). Plots were 0.28 acres (1200 plants, 'Coker 176') and were arranged in a randomized complete block design with two treatments and four blocks. The two treatments consisted of 1) aphid management (biweekly treatment with Orthene TIS at 0.50 lb Ai/acre) and 2) no aphid management (untreated with aphidicides). Plots were monitored and when foliage feeding insects were at economic

thresholds they were treated with selective insecticides (budworms and hornworms were treated with Dipel 2X; flea beetles were treated with Sevin XLR). The center four plants in each plot (the middle two plants in the center two rows) were inoculated with a local strain of PVY two weeks after transplanting. Plots were monitored throughout the season (13 and 27 June, 11 July and 22 August) and evaluated for PVY. All symptomatic plants were recorded by row and plant.

As the season progressed, the number of plants showing signs of infection increased (Table 1). The spread of virus was very low in the plots and not significantly different between treatments ($P > 0.05$). The density of aphids in a plot was uncorrelated with the level of PVY infection at the end of the season. In the plots managed for aphids, very few aphids were allowed to build up between treatment (the percent of plants infested with aphids was <1 %). In the unmanaged plots, aphid populations were very large (over 90 % of the plants infested with aphids). This experiment is planned to be repeated in 1987 to confirm the results from our 1986 experiments. We feel this information is necessary for the development of sound management programs for aphids and viruses in tobacco.

Table 1. Average number of tobacco plants infected with PVY. Values represent new infections per sample interval. Carteret County, NC, 1986.

Treatment	13 June	27 June	11 July	22 August
Aphid management	0.50	3.75	7.50	12.00
No aphid management	1.25	6.00	7.75	19.50
Probability of a > Treatment F	0.39 NS	0.42 NS	0.97 NS	0.20 NS

C. Effects of Host-Plant Health on the Bionomics of the Green Peach Aphid

The objective of this research was to determine the effects of host-plant health (infected with tobacco etch virus [TEV] or healthy) on the attraction to alighting aphids.

This research was conducted on excess allotment tobacco ('NC 2326' in 1985 and 'Coker 176' in 1986) grown in Duplin County, North Carolina. In each year, the field was divided in plots (20 plots 19 rows by 22 plants in 1985, and 16 plots 16 rows by 22 plants in 1986) that were solid set (no vacant rows). In the center of one

half of the plots, four plants (2 center plants in the middle two rows) were inoculated with Tobacco Etch Virus (TEV) one to two weeks after transplant. Nine clear bottomed alighting traps were placed in each plot in a systematic pattern. Traps were positioned in a plot such that in each inoculated plot, one alighting trap would be positioned over a TEV inoculated plant. This was done to ensure that some of the traps would always be positioned over healthy and TEV infected plants as the disease spread through the field. After the traps were properly positioned over a top leaf of the tobacco plants, ethylene glycol was poured into the trap as a preservative. Aphids were collected form the traps once per week and stored in alcohol in labelled vials for later identification. The traps were then cleaned, repositioned over a top leaf of the tobacco plant, and given a fresh supply of ethylene glycol.

The results of these experiments are presented graphically in Figure 1 (Note: the X axis of the figure begins on the first date TEV symptoms were visible on a tobacco plant under an alighting trap). In both years, there was a large difference between the mean number of aphids/trap/week over healthy and TEV infected plants early in the season. Significant differences ($P > 0.05$) between these catches were observed on Julian dates 165 and 172 in 1985, and Julian date 163 in 1986. As the season progressed, the difference in catch between these two plant health categories decreased. The aphids collected during 1985 have been identified to species. From these species, those known to vector POTY-viruses and those known to vector TEV specifically were separated and analysed separately. The catch of both of these groups of vector species was found to be significantly different ($P < 0.01$) due to plant health on Julian date 172. These experiments show that the tobacco plants infected with TEV early in the season attract more alighting aphids early in the season as compared with healthy plants. The reasons for this are unknown, but field experiments are planned for the 1987 season to examine these findings in more detail. The interactions between the aphid vectors and the virus infected plant can greatly effect the spread of a virus through the field and are essential pieces to the virus management puzzle.

IIA. Graduate Students:

- Committee Chairman - Ms. Randi Wilfert (Ph.D. Co-Chairman)
  - Mr. Christopher Harlow (M.S.)
- Committee Member - 1 (M.S.)

IIB. Special Students:

- Ms. Sheryl Brown - R.J. Reynolds Undergraduate Research Apprentice
- Ms. Carla Dennis - R.J. Reynolds Undergraduate Research Apprentice

III. Postdoctoral Fellows: None

IV. Publications:

Throne, J. E. and E. P. Lampert. 1985. Age-specific honeydew production and life history of green peach aphids (Homoptera: Aphididae) on flue-cured tobacco. Tob. Sci. 29:149-152.

Throne, J. E. and E. P. Lampert. 1986. Influence of plant age on honeydew production by green peach aphids (Homoptera: Aphididae) on tobacco. Tob. Sci. 30:39-40.

Gray, S. M. and E. P. Lampert. 1986. Seasonal abundance of aphid-borne virus vectors (Homoptera: Aphididae) in flue-cured tobacco as determined by alighting and aerial interception traps. J. Econ. Entomol. 79:981-987.

Duke, M. E. and E. P. Lampert. 1986. Sampling procedures for tobacco flea beetles (Coleoptera: Chrysomelidae) in flue-cured tobacco. J. Econ. Entomol. 80:81-86.

Lampert, E. P. 1986. Control of tobacco budworms and tobacco hornworms with Bacillus thuringiensis var. Kurstaki, 1985. Insect. and Acar. Tests 11:361-362.

Lampert, E. P. 1986. Control of tobacco budworms and tobacco hornworms with foliar insecticides, 1985. Insect. and Acar. Tests 11: 362-363.

Lampert, E. P. 1986. Control of tobacco wireworms with soil and transplant water insecticides, 1985. Insect. and Acar. Tests 11: 364.

V. Manuscripts Accepted for Publication:

Lampert, E. P. and P. S. Southern. Evaluation of pesticide application methods for control of tobacco budworms (Lepidoptera: Noctuidae) in flue-cured tobacco. Accepted by J. Econ. Entomol.

Lampert, E. P. and A. S. Stephenson. Control of tobacco budworms with foliar insecticides, 1986. Accepted by Insect. and Acar. Tests 12.

Lampert, E. P. and A. S. Stephenson. Control of tobacco budworms with various formulations of Bacillus thuringiensis var. Kurstaki and acephate, 1986. Accepted by Insect. and Acar. Tests 12.

Lampert, E. P. and A. S. Stephenson. Control of wireworms and aphids with soil insecticides and nematicides, 1986. Accepted by Insect. and Acar. Tests 12.

Southern P. S. and E. P. Lampert. Control to vegetable weevils with foliar insecticides, 1986. Accepted by Insect. and Acar. Tests 12.

VI. Manuscripts in Review:

Gray, S. M. and E. P. Lampert. Relationship between inoculum density and vector phenology on the incidence of potato virus Y in tobacco. Completed departmental review process and being revised for submission to Ann. Appl. Bio. in March 1987.

VII. Presentations at Professional Meetings:

Duke, M. E., E. P. Lampert and P. S. Southern. The phenology and distribution in the soil of the tobacco flea beetle. National Entomol. Soc. Amer. Meetings. Reno, NV. Dec. 9, 1987 (Read by P. S. Southern)

Wilfert, R. V. and E. P. Lampert. Relative attractiveness of healthy and tobacco etch virus (TEV) infected plants to aphids. National Entomol. Soc. Amer. Meetings. Reno, NV. Dec. 9, 1987.

Lampert, E. P. Development of sequential sampling procedures for tobacco flea beetles. 32nd Tobacco Workers Conference, Baltimore, MD. Jan. 14, 1987.

Southern, P. S. and E. P. Lampert. Evaluation of *Bacillus thuringiensis* baits and application techniques for control of the tobacco budworm, *Heliothis virescens* (F.), in flue-cured tobacco. 32nd Tobacco Workers Conference, Baltimore, MD. Jan. 14, 1987.

Lampert, E. P. Green peach aphid: status of the pest. 32nd Tobacco Workers Conference, Baltimore, MD. Jan. 13, 1987.

VIII. Graduate Student Thesis Completed During Reporting Period:

Duke, Michael Edward. 1986. The tobacco flea beetle, Epitrix hirtipennis (Melsheimer): seasonal abundance and sampling in flue-cured tobacco. M.S. Thesis, Department of Entomology, NCSU. 128 pp.

IX. Acknowledgments:

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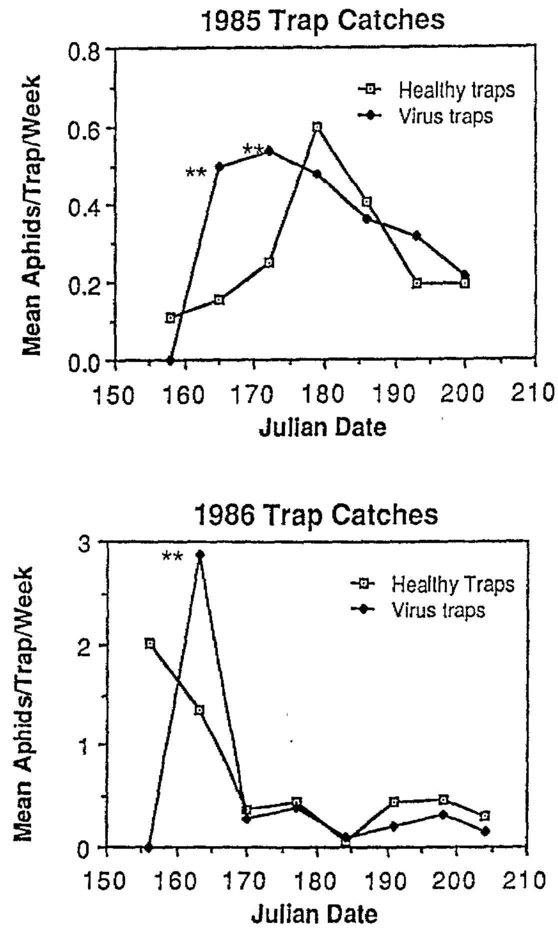

Figure 1. Relationship between Julian date and mean number of alate aphids caught per trap per week over healthy and Tobacco Etch Virus infected tobacco plants. ** = significant at the P=0.01 level.

Title: NC 00573 Management Strategies for Tobacco Insect Pests

Project Leader: D. Michael Jackson

I. Summary of Research:

A. Host Plant Resistance studies.

1. The ovipositional responses of tobacco budworm, *Heliothis virescens* (F.), and tobacco hornworm, *Manduca sexta* L., moths toward 65 *Nicotiana* species were evaluated in choice tests with NC 2326 flue-cured tobacco in field cages during 1984-86. Egg-laying on the various *Nicotiana* species ranged from nearly none to over 100% of the numbers deposited on the flue-cured check (Table 1, * = significant at 5% level, ** = significant at 1% level, NS = Not Significant, T-test). Additionally, tobacco budworm oviposition on 24 of the *Nicotiana* species was determined in no-choice tests in the same field cages in 1986. Results were similar between choice and no-choice type experiments. Measures of tobacco budworm ovipositional response were positively correlated to levels of duvane diterpenes and sucrose esters found on the cuticular surfaces of leaves from the *Nicotiana* species. The distribution of the various acid moieties attached to the different sucrose esters and/or structural difference between sucrose esters from different *Nicotiana* spp. may be important factors in determining the activity of these compounds for stimulating tobacco budworm oviposition.

2. Natural populations of beneficial and pest insects were monitored in field plots containing 70 entries representing 65 *Nicotiana* species. Entries were planted in 3 replications of 12-plant plots in a randomized complete block at Oxford, NC and at Tifton, Ga. Green leaf samples were taken from each entry for analyses of leaf surface chemicals. Insect resistance and cuticular chemistry among the *Nicotiana* species varied widely.

3. The sucrose esters from TI 165 were extracted, formulated, and sprayed onto the leaves of a tobacco budworm-resistant (by ovipositional nonpreference) tobacco entry at rates of 1/16X, 1/8X, 1/4X, 1/2X, X, and 2X, with X being the typical field rate of 60 g/cm^2 of leaf surface. These plants were bioassayed for tobacco budworm oviposition by choice tests with unsprayed plants in field cages. Although all of the rates of sucrose esters increased egg laying, no significant dose-response relationship could be established.

4. The sucrose esters from *Nicotiana alata* and *N. trigonophylla*, and 15-OH abienol from *N. glutinosa* were sprayed onto the leaves of a tobacco budworm-resistant (by ovipositional nonpreference) tobacco entry and bioassayed as described above for tobacco budworm ovipositional preference. *N. trigonophylla* sucrose esters significantly increased tobacco budworm oviposition on the sprayed plants, but the other treatments were inactive.

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Table 1. Ovipositio
Oxford, NC

Nicotiana Species	N.spp. Number
glauca	23
goodspeedii	25
excelsior	19
acaulis	1
cordifolia	15
petunioides	42
undulata	61A
thyrsiflora	57
wigandioides	63
suaveolens	55
knightiana	27
rosulata	53
debneyi	17
ingulba	64
fragrans	22
arentsii	6
solanifolia	52
linearis	29
maritima	31
hesperis	67
miersii	33
noctiflora	35
nudicaulis	36
cavicola	68
velutina	62
exigua	20
megalosiphon	32
attenuata	7
rustica v. pavonii	44
spegazzinii	70
plumbaginifolia	43A
pauciflora	41
africana	71
bigelovii	10
rotundifolia	47
longiflora	30
gossei	26

5. The ovipositional responses of tobacco hornworm moths toward two resistant (I35 and TI 1112) and two susceptible (NC 2326 and Speight G-33) tobacco entries were determined in field-cage experiments. When plants were clumped by individual entry in each corner of the cages, the percentage of eggs deposited on each type was: NC 2326 - 29.2%, Speight G-33 - 27.8%, TI 1112 - 27.4%, and I-35 - 15.6%. When plants were intermixed in each corner of the cage, the percentages were: NC 2326 - 31.1%, Speight G-33 - 27.9%, TI 1112 - 24.9%, and I-35 - 16.1%. These data contrast with results of 1985 field tests where the distribution of naturally deposited wild eggs was: NC 2326 - 41.0%, Speight G-33 - 48.1%, I35 - 6.4%, TI 1112 - 4.5%.

Table 1. Ovipositional responses of tobacco budworm and tobacco hornworm moths to *Nicotiana* spp., Oxford, NC, 1984-86.

Nicotiana Species	N.spp. Number	Percent of Eggs on N.spp. — Budworms: Choice Test	Budworms: No-Choice Test	Hornworms: Choice Test
glauca	23	0.1**	0.2**	7.3**
goodspeedii	25	0.9**	-	27.4**
excelsior	19	1.9**	1.8**	28.0**
acaulis	1	6.0**	-	12.3**
cordifolia	15	6.7**	-	27.1**
petunioides	42	6.8**	-	5.7**
undulata	61A	7.6**	8.3**	30.0**
thyrsiflora	57	7.7**	-	17.6**
wigandioides	63	9.5**	10.2**	35.0NS
suaveolens	55	9.6**	7.9**	12.3**
knightiana	27	10.5**	16.0**	43.2NS
rosulata	53	11.0**	-	26.6*
debneyi	17	12.2**	-	28.9**
ingulba	64	12.9**	-	12.9**
fragrans	22	14.3**	2.3**	6.7**
arentsii	6	14.4**	14.7**	44.9NS
solanifolia	52	14.7**	-	18.1**
linearis	29	15.2**	-	16.8**
maritima	31	17.9**	-	28.7*
hesperis	67	18.2**	-	13.6**
miersii	33	19.9**	-	11.0**
noctiflora	35	20.5**	-	-
nudicaulis	36	21.6**	-	24.9**
cavicola	68	21.8**	31.9*	30.2**
velutina	62	22.7**	-	37.5*
exigua	20	24.1**	-	18.6**
megalosiphon	32	25.2**	-	28.1**
attenuata	7	25.7**	-	14.5**
rustica v. pavonii	44	26.2**	-	46.5NS
spegazzinii	70	-	-	18.0**
plumbaginifolia	43A	27.6**	27.4**	26.7**
pauciflora	41	28.1**	-	39.1NS
africana	71	28.6*	-	23.9**
bigelovii	10	29.4**	-	29.0**
rotundifolia	47	30.4NS	-	11.3**
longiflora	30	31.1*	-	34.1*
gossei	26	31.4**	21.0**	28.8**
repanda	46	32.3*	13.8**	29.4**
stocktonii	54	33.5NS	-	42.0NS
tomentosa	58	34.4NS	-	48.1NS
raimondii	45	34.4NS	14.9**	27.9*
amplexicaulis	65	34.6*	-	44.9NS
clevelandii	14	34.7NS	-	22.6**
rustica v. brasilia	48	39.4NS	-	32.0*
benavidesii	8	40.0NS	-	26.2**
acuminata	2	40.5NS	-	38.9NS
otophora	38	40.6NS	12.1**	47.5NS
simulans	66	40.7NS	-	25.1**
bonariensis	11	41.0NS	-	44.2NS
tomentosiformis	59	41.9NS	29.3*	46.2NS
langsdorfii	28A	42.0NS	39.3NS	43.8NS
paniculata	40	43.5NS	-	40.3NS
benthamiana	9	45.2NS	47.8NS	47.5NS
umbratica	69	45.5NS	-	41.7NS
glutinosa	24A	45.7NS	-	38.7NS
occidentalis	37	45.9NS	-	32.4*
palmerii	39	47.8NS	-	26.0**
setchellii	51	48.6NS	-	36.1NS
rustica v, pumila	49	49.2NS	-	29.5**
nesophila	34A	49.5NS	21.9**	34.6*
tabacum cv NC 2326	-	(50.0)	(50.0)	(50.0)
alata	3	50.4NS	50.0NS	38.7NS
glutinosa	24	50.6NS	47.7NS	47.5NS
sylvestris	56A	51.4NS	44.6NS	52.5NS
glutinosa	24B	51.6NS	-	45.3NS
forgetiana	21A	51.6NS	-	27.4**
kawakamii	72	52.0NS	43.0NS	51.2NS
tabacum cv. Samsun	(00)	56.8NS	-	54.0NS
trigonophylla	60	65.8NS	37.0NS	41.9NS
corymbosa	16	-	-	-

6. As part of an on-going screening program of tobacco germplasm, 70 tobacco entries were evaluated for insect resistance in replicated field plots at Oxford, N.C. and Tifton, Ga. Leaf surface chemical components were also monitored on these plots, to help establish relationships between cuticular chemistry and insect pest responses. Flower samples for polyphenol studies were also taken.

7. Several advanced breeding lines were evaluated for agronomic, chemical, and insect-resistance qualities. From these efforts, a tobacco budworm-resistant breeding line, NCI514, is being prepared for release by North Carolina State University. We evaluated advanced breeding material in greenhouse and field feeding bioassays with tobacco budworm larvae. During 1986, nine individual F5 selections, which were developed from NC 82 and TI 165 parents, were chosen for final evaluation. Several of these entries were highly resistant to feeding by tobacco budworm larvae, and one entry processing acceptable agronomic chemical traits was chosen for release.

8. Alkaloid development was monitored over time and over leaf position in two check tobacco entries (TI 165 and NC 2326) and in four isogenic (From NC 95) tobacco lines varying only in alkaloid levels. Samples for alkaloid analyses were taken every 2 weeks starting from plant bed seedlings through the cured leaves. Samples were taken at several leaf locations (a-e) on the plants, and on weeks 10 and 14 after transplanting additional samples were taken to determine within-leaf alkaloid distribution. During weeks 4, 8, 12 and 16, second-instar tobacco budworm larvae were placed in perforated plastic bags on the test plants. Their survival and weight gain were evaluated after one week. Total alkaloid levels for these six tobacco entries ranged from 0.34 to ca. 3.5% of total dry weight of cured leaves. However, alkaloids in growing leaves are at much lower levels, and they are translocated from the roots as then leaves mature. Since leaves ripen from the bottom of the plant upwards, the lower leaves generally have higher alkaloid levels than younger leaves above. The survival and development of tobacco budworm larvae closely followed the alkaloid distributions. Larvae developed at the highest rates in the buds of a particular entry. More larvae survived on the lower leaves of the low alkaloid lines than on the lower leaves of the high alkaloid lines. When the plants were small, at week 4, there were little differences in alkaloid levels between leaf position a (top) and b. By week 8, levels were much higher in the lower leaves. Plants were topped at week 10. At week 12, for the topped plants, this pattern begins to change slightly, as more alkaloids are translocated to the upper leaves. By week 16, there were only slight differences in the alkaloid levels between the top leaves (a') and those down 9 or 10 leaves (c). This pattern continues, and by harvest the upper leaves normally contain more nicotine than the lower leaves. Alkaloid levels in the bud leaves remain at low levels over the season. This is the part of the plant

attacked by Heliothis larvae. At any leaf position there were significant negative correlations between budworm survival and levels (logarithm) of total pyridine alkaloids.

B. Bacillus thuringiensis studies.

Ten formulations of Bacillus thuringiensis var. kurstaki (B.t.k.) and two formulations of Thuringiensin (-exotoxin), a secondary metabolite of certain B.t. strains, were tested for control of tobacco budworm and tobacco hornworm larvae on flue-cured tobacco in field tests. All granular formulations of B.t.k. gave superior tobacco budworm control over liquid and wettable powder formulations at equivalent rates of active ingredient. All B.t.k. formulations gave good tobacco hornworm control. Thuringiensin formulations gave fair tobacco budworm control at higher rates, but they were not effective against tobacco hornworms. The wettable powder formulation of Thuringiensin was severely phytotoxic to flue-cured tobacco.

C. Insect Monitoring Program

1. A tobacco insect pest monitoring program was continued in Granville County, NC. Adult tobacco budworms; tobacco hornworms, and tomato hornworms were collected weekly from 8 traps each of 3 different types: (1) wire cone traps baited wtih Virelure, (2) electric grid traps baited with Virelure, and (3) blacklight traps. An insect monitoring program has been in continuous operation since 1962. These data are useful in recognizing patterns of pest or beneficial species fluctuations. The importance of certain pest species have changed over the years, which may be correlated to changes in cultural practices of insecticide-use patterns.

2. In conjunction with our host plant resistance studies, cone-type traps, baited with a commercial preparation of Virelure that attracts male tobacco budworm moths, were monitored at Oxford, NC and Tifton, Georgia for the 5th years. Data are being combined with past and future information on Heliothis captures in order to more accurately predict peak adult population levels. These predictions will be used to better plan field experiments and for determining optimum planting dates for host plant resistance field screening tests. Similarly, data from blacklight traps at Oxford and Tifton are being used to predict hornworm outbreaks.

3. As part of a multi-state Heliothis spp. monitoring program six Heliothis virescens and six H. zea traps were monitored on the Tobacco Research Station, Oxford, N.C. We used the cone 75-50 Texas Traps, and lures were provided by the Texas group (Goodenough and Lopez.)

D. Insect Rearing Activities.

We maintain laboratory colonies of tobacco budworms, tobacco hornworms and Cotesia congregata. The colonies are primarily intended for our own use, but excess insects were sent to several cooperators throughout the United States. The Cotesia colony was obtained from the University of Maryland, and it is now in its 7th generation at Oxford.

E. Minimum Tillage Experiments.

In a cooperative experiment with NCSU soil entomologist, Gar House, we studied for the second year the survival of tobacco budworm pupae in tobacco plots with several tillage schemes. Beneficial predators are higher in no-till and mulched plots. These insects will feed on tobacco budworm pupae.

II. Graduate Students: None

III. Postdoctoral Fellows: None

IV. Publications:

Jackson, D. M., R. F. Severson, A. W. Johnson, and G. A. Herzog. 1986. Effects of cuticular duvane diterpenes from green tobacco leaves on tobacco budworm (Lepidoptera:Noctuidae) oviposition. J. Chem. Ecol. 12:1349-1359.

Jackson, D. M., V. A. Sisson, and R. F. Severson. 1986. Tobacco budworm and tobacco hornworm ovipositional preference for Nicotiana spp. Annu. Plant Resist. Insects Newsl. 12:28-30.

Jackson, D. M. 1986. Control of tobacco budworms with β-exotoxin from Bacillus thuringiensis and with B.t. cornmeal baits, 1985. Insect. Acar. Tests 11:359-360.

Jackson, D. M. Control of tobacco pests with Bacillus thuringiensis var. kurstaki formulations, 1985. Insect. Acar. Tests 11:360-361.

Goodenough, J. L., J. J. Gaylor, V. E. Harris, T. F. Mueller, J. Heiss, J. R. Phillips, G. Burris, K. J. Ratchford, D. F. Clower, A. M. Pavloff, R. L. Rogers, H. N. Pitre, J. W. Smith, A. H. Baumhover, J. J. Lam, Jr., K. D. Elsey, D. M. Jackson, C. M. Knott, J. H. Young., L. J. Wilson, S. H. Roach, M. Shephard, J. D. Lopez, Jr., G. J. Puterka, J. E. Slosser, and W. L. Sterling. 1986. Efficacy of Entomophagous Arthropods. Pages 75-91 In Theory and Tactics of Heliothis Population Management: 1-Cultural and Biological Control, S. J. Johnson, E. G. King, and J. R. Bradley, Jr. (eds), Southern Coop. Ser. Bull. 316, 161 pp.

V. Manuscripts in Review:

Jackson, D. M., R. F. Severson, A. W. Johnson, G. R. Gwynn, J. F. Chaplin, V. A. Sisson, and G. A. Herzog. Host plant resistance in tobacco to Heliothis species. Paper presented at the Southern Regional Project S-59, "Heliothis spp: Management Systems for Field Crops", Workshop III. Emerging Control Tactics and Techniques for Heliothis. March 26, 1985. Little Rock, Arkansas.

Jackson, D. M., A. W. Johnson, R. F. Severson, J. F. Chaplin, and M. G. Stephenson. Levels of cuticular components and insect damage on green leaves of normal, late-planted, and ratoon tobacco. (In peer review).

VI. Manuscripts Accepted for Publication:

Jackson, D. M. 1987. Control of tobacco insect pests with Bacillus thuringiensis var. Kurstaki and Thuringiensin formulations, 1986. Insect. Acar. Tests 12: (In Press).

VII. Papers Presented at Professional Meetings:

Jackson, D. M. 1986. Analysis of ovipositional nonpreference mechanisms in Nicotiana spp. Invited paper presented at Seventh Biennial Plant Resistance to Insects Workshop as part of a Symposium: Tobacco Alkaloids and PRI, March 18-22, 1986, Kansas State University, Manhattan, Kansas.

Jackson, D. M., R. F. Severson, and V. A. Sisson. 1987. Tobacco budworm oviposition on Nicotiana species. Paper presented at 32nd Tobacco Workers Conference, Jan. 12-15, 1987, Baltimore, Maryland.

House, G. J., D. M. Jackson, and D. P. Schmitt. 1987. Influence of no-trillage practices on soil arthropods and nematodes of tobacco. Paper presented at 32nd Tobacco Workers Conference, Jan. 12-15, 1987, Baltimore, Maryland.

Jackson, D. M., R. F. Severson, and J. F. Chaplin. 1987. Survival and development of Heliothis virescens (F.) larvae on isogenic tobacco lines differing in alkaloid level. Paper presented at 61st Annual Meeting of the Southeastern Branch of the Entomological Society of America, Jan. 26-29, 1987, Jackson, Mississippi.

VIII. Graduate Student Thesis: None

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